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FERTILIZER

EXTENSION WORKER SHOWS FARMERS
IN MALAWI HOW TO APPLY FERTILIZER
(PHOTO: FAO)

Fertilizer Issues in the 1970s and Beyond

Graham F. Donaldson

[In 1973-74 world prices for fertilizers rose to nearly triple the levels of 1972-73, and shortages in availability became widespread. Although prices have since declined somewhat, agriculture has been affected. The causes and implications of these effects for less developed countries (LDCs) are discussed, first for the short run and then from a longer run perspective involving world supplies of food.]

Short Run Situation

The production and use of fertilizer has been expanding at a rapid rate. There has not been a decline in annual world fertilizer production for either nitrogen, phosphate or potash at any time in the past 15 years (see Table 1), and there are only one or two instances where production in any one country has declined. Consumption has been growing at rates comparable to production, but there have been periods of surplus or shortage relative to demand and corresponding price swings. Everything points to the recent fertilizer shortage being primarily demand-related, reinforced by a reduced rate of growth in fertilizer production capacity in the immediate past and various constraints on the manufacturing side which have prevented a rapid supply response. A confluence of events can be traced which has determined the nature of the shift on both the demand and supply sides. While some of these factors seem likely to disappear as rapidly as they appeared, there may well be some lasting effects on both the industry and on agriculture.

Prices increased sharply in 1974 for all the main plant nutrients — phosphates (P), potash (K) and nitrogen (N) —

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see Table 2. The problem is least serious for potash since lower amounts are used in crop production, the supply shortfall was less acute (being mainly due to transportation bottlenecks), and additional supplies were forthcoming quickly. The problem was also less serious for phosphate in that (like potash production) it is not directly affected by crude oil supplies and new production capacity is under construction, and because a reduced application of phosphate to crops for a season or so will (at least under temperate conditions) have relatively small effects on yields for most crops (phosphate is stored in the soil whereas nitrogen is readily lost to the air).

Table 1: World Fertilizer Production 1960-1975
(1000 metric tons)

	Nitrogen		Phosphate		Potash	
	tons	% change	tons	% change	tons	% change
1960	9977		9741		8707	
1961	10884	9.1	10095	3.6	8770	0.7
1962	11882	9.2	10376	2.8	9360	6.7
1963	13152	10.7	11055	6.6	9814	4.8
1964	14875	13.1	12462	12.6	10800	10.0
1965	16870	13.4	13840	11.1	12127	12.4
1966	19138	17.1	15083	9.0	13768	13.5
1967	22403	14.2	17033	12.9	14512	5.4
1968	25498	13.8	18012	5.7	15347	5.8
1969	28384	11.3	18587	3.2	15969	4.1
1970	30134	6.2	19274	3.7	16898	5.8
1971	32920	9.2	20775	7.8	17872	5.8
1972	34999	6.3	22388	7.8	19469	9.0
1973	38028	8.7	23686	5.6	20198	3.7
1974	40756	6.8	25300	6.8	22100	9.4
1975[1/]	41500	2.2	27500	8.7	23500	6.3

1/ Estimates of the UNIDO/FAO/IBRD Ad Hoc Working Group on Fertilizers, April 1975

SOURCE: FAO Annual Fertilizer Review, 1960-63, 1965, 1966, and 1973

Table 2: Indices of World Prices for Principal Fertilizers, 1967-75, and Forecasts to 1985
(1973 = 100)

	Actual Prices				Forecast Prices (1973 dollars)			
	1967-69	1970-72	1974	1975	1976	1977	1980	1985
Phosphate Rock	121	100	321	357	343	293	200	207
T. S. P.	61	64	253	199	127	116	96	97
DAP	78	73	230	171	186	166	130	136
Urea	105	68	274	216	201	166	107	122
Muriate of Potash	84	95	116	121	126	116	107	98

SOURCE: World Bank, Economic Analysis and Projection Department.

The major concern relates to nitrogen fertilizer. It is on HYV (high yielding varieties) crop responses to nitrogen that the "green revolution" food production strategy is predominantly based. Consequently, constraints on supplies and increased prices for nitrogen fertilizer have far-reaching implications for the agriculture and food supplies of many developing countries. The manufacture of nitrogenous fertilizers depends predominantly on oil or natural gas-fired processes. Since the same inputs are used in the production of many crop protection chemicals, the problem may be compounded — since such chemicals are also a feature of modern crop production technology.

Demand-related effects. Since the demand for fertilizer is a derived demand, it is to be expected that a major shift of the kind we have experienced will be underlain by changes in the demand for crop products, especially cereals. Several factors have influenced this change. First there is a long-term upward trend caused by (1) growing population, (2) increases in incomes, and (3) changes in consumption patterns.

The growth in population is the most stable factor affecting the increased growth in demand for food, especially cereals. This is presumably causing an overall increase in aggregate demand for food of some two percent per year, although in some countries it is greater and in others smaller due to differences in rates of population growth. Significantly, the higher rates of growth are in countries that are fertilizer deficient, and hence importers (mainly LDCs). The demand from this source is reinforced by the fact that the HYV technology, which is currently the primary means of increasing domestic food supplies in the LDCs, is highly dependent on fertilizer.

Added to this is the increase in demand for food associated with the growth in incomes. Incomes increased substantially in many countries through the sixties, especially in the U. S., Western Europe and Japan, but also in Eastern Europe and some other countries. Although the

direct effects of rising incomes on food prices are usually small, due to the relatively low income-elasticity of demand for food, there has undoubtedly been some increase in demand due to income effects. The exception to the low-income-elasticity-for-food argument occurs when people trade-up to superior goods, especially by increasing their consumption of meat. This shift can cause a disproportionate increase in the demand for grains — one pound of meat requires some four pounds of grain to produce. Although meat consumption has grown only some 2-3 percent annually over recent years, a fairly small rate of expansion, this has added disproportionately to the demand for feedgrains — mainly in the developed countries.

Despite the steady upward pressure on fertilizer demand from these long-term trends there is nothing here to explain the recent surge in demand. However, there was a series of abnormal effects on the demand for and production of foodgrains including: (1) a run-down of world grain stocks, (2) widespread crop failures, (3) sudden changes in the patterns of trade in foodgrains, and (4) a sudden acreage expansion encouraged by government action in the major grain exporting countries.

A seemingly deliberate run-down in the world stocks of foodgrains, mostly held in the large exporting countries, was perhaps the most significant factor underlying the current situation. The acreage of wheat grown in the U. S. in 1970 was 80 percent of that in 1968 and 74 percent of the 1967 acreage, and the lowest since 1948. In the U. S. some 60 million acres of cropland were held out of production through 1970-72 — nearly 20 percent of the total arable area. Similarly, due to acreage restrictions, Canada's wheat acreage in 1970 was only half the 1969 acreage and Australia's acreage was cut to 60 percent of its 1968 acreage. The effect of these acreage constraints was to cut the level of stocks held in those countries substantially. Reinforcing this shift, there were widespread crop failures in 1972 which resulted in many countries, notably India and others in Asia, importing more foodgrains than they would otherwise have done. As a consequence a severe shortage of wheat developed in 1972, to the extent that the FAO reported stocks at the end of 1972 to be at "dangerously low levels." On top of this, the USSR entered the market in early 1973, buying 12 million tons of wheat from the U. S. alone. This turned the tight supply situation into a severe shortage.

Somewhat belatedly, in response to this largely unforeseeable situation, the major exporting countries in 1973 raised quotas, released "set-aside" land and encouraged widespread cereal planting. Wheat acreages in the main exporting countries rose by more than 10 percent in 1973 and another 10 percent in 1974. The demand for fertilizer expanded equally suddenly. Further, since fertilizer is also used on non-cereal crops, there were derived demand effects relating to expansion in their production. In this category there were also several influences:

an upsurge in demand for industrial crops; a steep rise in the price of soybeans; and diversion of some urea to livestock feed.

The economic upswing in all Western countries in 1972-73 that caused an increased demand and resulting higher prices for all basic commodities, also caused an increase in demand for industrial crops. The prices of oilcrops, coarse fibers, cotton and rubber, all increased in the early 1970s — some by fantastic amounts. This was accompanied in 1973 by the sudden disappearance of the already depleted stock of anchovy off the coast of Peru — the major source of fishmeal used in livestock feeds. This had two effects: First, there was a significant demand increase for soybean meal as an alternative, and prices rose fourfold, encouraging extra planting. Second, urea (otherwise used for fertilizer) was used as a protein substitute in feedmixes. Thus, this capricious event caused a double demand effect on the fertilizer industry. (The anchovy have since returned — at least for the time being!)

Supply-related effects. The supply of fertilizer has not been subject to variations of the same magnitude as demand. However, it has been subject to a series of interacting events which have resulted in both a slower rate of output growth in some recent years (see Table 1) and, perhaps more importantly, in a number of constraints upon the ability of the industry to respond quickly to the changing demand situation. These events include: (1) a changing pattern of ownership, especially in the U. S., (2) changing technology and scale advantages leading to larger plants, (3) the disposal of inefficient plants, and (4) some shifts in the location of manufacture.

The changing pattern of ownership was largely a response by oil and gas firms who sought an outlet for their gas supplies through fertilizer. Some of these firms bought existing fertilizer plants, but in most cases they started from scratch or expanded by building new plants. The emergence of these new large suppliers contributed to the surplus situation in the second part of the sixties. At the end of the sixties many of the older plants were sold off to agricultural cooperatives and established fertilizer companies, though some remained in the hands of oil and gas corporations.

Some major changes in processing technology in the sixties led to a new generation of fertilizer plants where there were considerable economies of scale. Some of the 60-odd manufacturers in the U. S. then became giants in the field. It also meant that there was a considerable increase in the "lumpiness" of capital investment in production capacity, and this may be a significant determinant of the investment cycle characteristics in the future. These modern plants made smaller plants of an earlier vintage relatively expensive to run, and led to their early retirement when the market proved inadequate to

maintain them profitably — no doubt to the chagrin of their managers in 1974. With the installation of new plants there was some shift in location within the U. S. and Europe, away from the former coal and steel centers toward the ports and fuel sources. In the global context there was also some growth of production capacity in LDCs — both in the oil and gas producing countries (e. g. Venezuela and Persian Gulf) and in the consuming countries (e. g. India and Indonesia). While these adjustments could not have contributed to a supply deficit in any major way, it is perhaps important that they caused a situation of change and uncertainty within the manufacturing industry which made rapid adjustment to the sudden expansion of demand even more difficult than it was otherwise. Such a volatile situation almost certainly added to the degree of imperfect knowledge surrounding the planning and investment process.

Related to these structural adjustments within the industry is an established cycle of investment in production capacity which has recurred irregularly since World War II. All evidence suggests that the recent resurgence in demand coincided with a low point in the swing of this cycle. Thus, there was a delay in the supply response until new plant came on stream, and new investment was implemented. As this happened there were some inevitable teething troubles, and the industry found itself with a greater demand than it could satisfy — at least in the short run. Reinforcing the structural and cyclical effects there were also many operational constraints, arising from: the "energy crisis," environmental control regulations, world-wide shortages of basic raw materials and commodities, the shipping shortage, and low plant capacity utilization.

The "energy crisis" contributed to some extent, especially in providing alternative demands for the gas and ammonia which are the chief feedstocks for nitrogen fertilizer, and in delaying the supply of other inputs. The shortage of feedstocks is known to have led to the closure of some plants in the LDCs and to reduced output from some plants in Japan, and it clearly restricted any rapid expansion of output in many other situations. In addition, the introduction of environmental protectior regulations caused some restraints on capacity utilization, and restricted an output response to higher prices. Along with other industries, the fertilizer industry encountered a shortage of basic inputs (other than gas and oil), and delays in new plant deliveries caused by scarcities associated with the concurrent peaking of the major Western economies. This not only drove up the price of basic commodities but caused shortages of steel and other metals. It also contributed in large measure to a worldwide shortage of shipping capacity; this affected both the delivery of rock phosphate and the distribution of finished fertilizers to importing countries, while the higher shipping rates added to fertilizer costs. Another contributing factor was the low level of capacity utilization in many plants. In some cases this was of an acute short-run nature, due to teething problems in the initial operation of new plant, to the non-availability of spares and replacements, or other

delays in deliveries. In other cases this problem was more chronic in character, especially in the LDCs.

There was also a group of problems on the marketing and distribution side of fertilizer supply. In addition to the shortage of international shipping tonnage, there was also a shortage of transport capacity within many countries. Rail cars were short in the U. S. and Canada — this affected both the distribution of finished fertilizer and the delivery of potash from Canada to both North American and overseas markets. India suffered a dislocation of rail services due to labor disputes. The Philippines was short of coastal shipping. Stocks of fertilizers were very low in some countries and in many regions within countries. This was due to inadequate storage capacity in some situations, in other places it followed from the need to replant crops following the poor seasons of 1972. In addition, there was a tendency toward speculation in stocks of fertilizer since, with visibly rising prices, it was profitable for merchants to hold stocks for as long as possible. There are reports that such hoarding reached significant proportions in some countries.

Finally, there were a series of changes which especially affected supplies of fertilizer to the LDCs, including: a reduction in supplies of aid-financed fertilizer from the U. S., the removal of price controls on fertilizer in the U. S. domestic market, and the disappearance of cheap by-products usually available from Japan. In 1968, USAID spent $175 million on fertilizers for export to the LDCs; in 1971 it was less than $50 million. Since then the dollar commitments have been increasing, but due to the price rise the quantities shipped have not returned to earlier levels. In addition, the price of fertilizer in the U. S. had been subject to price control regulations instituted in 1971; exports rose, as the relative profitability of the export market increased. But when the price constraints were removed in 1973, the rate of exports subsided as virtually all production was diverted to the domestic market. In recent years, too, there has been a technological breakthrough in the production of caprolactam in Japan. This reduced the amount of ammonium sulfate produced as a by-product by about half. This source of supply had been regularly drawn on by India, and has proved difficult to replace.

Current Implications for Agriculture

The chemical fertilizer industry exists, after all, solely because we need it as an input source in the production of food and fiber. The agricultural implications of the current fertilizer shortage are perhaps its most significant elements. World fertilizer consumption more than doubled in the ten years to 1972, reaching almost 80 million tons (see Table 1). Usage in the LDCs grew at a higher rate than in

developed countries, but the former accounted for only 14 percent of total consumption in 1972. This is projected to rise to 26 percent by 1980. The significance of fertilizer supplies to the LDCs is reflected in the estimate that 35 to 40 percent of the incremental growth of agricultural output is attributable to fertilizers. With a 5 percent cut in fertilizer supply, the foodgrain production in India, for instance, could fall by more than one million tons per year, which implies higher food prices and increased foodgrain imports. There is substantial evidence that the recent impact has in fact been more serious than this.

These effects have been accompanied by dislocations at the farm level. For those farms which are mechanized and irrigated, there has been the double effect of fuel and power price increases in addition to those for fertilizer. More serious, however, has been the fertilizer availability problem, since this led to the use of HYVs without fertilizer, in which case they yield little more than traditional varieties. Less mechanized farms, and those in rainfed areas, have been less seriously affected since they used less fuel and fertilizer in the first place.

Effects on farm costs. Farmers faced a threefold increase in the world price for fertilizer within the year 1973/74 which has been sustained through 1974/75 (see Table 2). Fertilizer and other chemicals costs range in proportion from zero to 40 percent of total farm costs depending on the production methods. This means that, in general, individual farm operating costs have risen from zero for subsistence small holders to as much as 100 percent for those using modern technology.

Clearly, the actual increase in costs will have varied with the level of fertilizer inputs used. Farm costs are also affected by government pricing policies for fertilizer. The cost impact has not been direct and simple, since farmers have responded to the price increases by various shifts in production patterns — changing to crops and varieties with lower fertilizer needs, using lower fertilizer dressings and substituting other inputs for fertilizer (such as green manuring). In this way the full impact of increased costs has been avoided; but some loss of income has been experienced — although offset in some cases and to some degree by increases in product prices.

Effects on farm product prices. Consequent upon changes in production costs and related shifts in output, an increase in price for farm produce is inevitable, unless there is administrative intervention. In fact, there have already been substantial price increases in the past two years. A crop failure in a country such as India, when coupled with fertilizer and fuel supply problems, could have led to massive domestic food shortages and food price increases. In practice, such an outcome was largely averted by effective policy measures, a favorable spring harvest in 1975 and judicious foodgrain imports,

some of it as food aid. To some extent, the increased acreage of crops being grown in the food exporting nations has offset the upward pressure on food prices on the world market; nevertheless, the impact on consumers has been great. Given that food is their major item of expenditure, the urban poor will undoubtedly have been the most severely affected.

Effects on output and income. A decline in agricultural output has been anticipated as a consequence of lower yields due to less fertilizer being applied. However, more complex shifts from existing cropping patterns to new ones have altered both the physical mix and value of output. Generally, acreages of leguminous crops (such as beans, peas and gram) have not been cut back. Other basic food crops, especially the one which is the traditional food crop in each area, has not declined either — if for no other reason than that they are needed for family subsistence, but also because food crop products have increased in price substantially in the short run (although in some countries they have been held down by administered pricing).

A most serious decline in physical output could occur in response to changes in the use of crop protection chemicals. While yields will decline more or less proportionally to the amounts of fertilizer used, omitting a spraying or using a greater dilution of active ingredient could lead to an infestation which virtually wipes out a crop. Failure to use appropriate sprayings by some farmers may have equally serious effects even for their neighbors who do. A shortage of such chemicals, or higher prices, since they have a relatively high elasticity of demand, could therefore have effects on output and incomes of much greater proportions than a comparable situation for fertilizers. These effects, however, are likely to be short lived — though they may be recurring. The very high commodity prices of the past two years have already begun to decline with the prospect of rebuilding foodgrain stocks and a fertilizer price decline. Given the rate at which new fertilizer capacity is being established (some 33 million tons of additional nitrogen manufacturing capacity is believed assured to come on stream within the next 5 years) severe shortages are likely to disappear quickly and prices to come down sharply, though they will probably be higher than in the past due to higher production costs. This does not reduce the seriousness of the near-term impact, especially in LDCs and particularly in South Asia.

Fertilizer and the Longer Run Outlook for Food Supplies

Over the past 20 years world population, food production and fertilizer consumption have increased at rates shown in Table 3. Food production trends can best be shown by totals for the output of cereal grains, on which relatively good figures are obtainable. In the LDCs

rice, wheat or corn represent the principal food staple in most cases; in the developed countries much of the grain goes to feed livestock, so that by inclusion of feedgrains the trends in consumption of meat, eggs and dairy products are represented in the grain total along with foodgrains. During 1953-73 grain production increased by 77% and population by 48%, leaving a per capita gain of about 20%.

Table 3. Changes in Population, Grain Production and Fertilizer Use, 1953-73

World	Population (millions)	Grain Production (million tons)	Fertilizer Consumption (million tons)	Grain Per Capita (kg)	Fertilizer Per Capita (kg)
1953	2615	775	17.4	296	6.7
1973	3860	1,374	77.2	355	20.1
Percent Increase	48%	77%	345%	20%	200%
Developed Countries					
1953	867	397	15.9	458	18.3
1973	1087	741	60.0	682	55.2
Percent Increase	25%	87%	277%	49%	203%
Developing Countries					
1953	1748	378	1.53	216	0.88
1973	2773	630	17.49	227	6.30
Percent Increase	59%	67%	1004%	5%	615%

SOURCES: U. N. Monthly Bulletin of Statistics, June 1975; 1973 Annual Fertilizer Review, FAO.

It must be recognized, however, that the greatest part of this gain occured in the developed countries, due to their faster growth in grain production and slower population increase. In the LDCs the per capita increment was only 5% for the 20 year period. The increase from 378 to 630 million tons of grain in these countries was a considerable achievement, made possible in part by the "green revolution" and all the research and investment that lay behind it; yet a 59% population increase brought down the average per capita increase to the 5% level. The population increase in LDCs from 1953 to 1973 was about 1.0 billion; according to the medium-level projection of the United Nations, there will be a further increase by the year 2000 of another 2.2 billion people in the LDCs. (This assumes a decrease in growth rates from today's 2.5% a year to 2.0%). A serious question arises as to where the food for these additional people will come from.

World grain output can, no doubt, continue to grow faster than world population. But if this means principally growth in the industrial countries along with relative stagnation in the LDCs, the latter will become increasingly dependent on food imports from the former. And such a dependency is not an appropriate solution. The LDCs' finite ability to accelerate their production of goods exportable to developed country markets and the apparent reluctance of industrial countries to buy an ever larger volume of such LDC exports, in conjunction with other LDC import needs, set limits to the practical possibilities of LDC dependence on food imports. Imported food may be the optimal solution for some countries; but for LDCs as a group, and probably for most of those with large populations, the only lasting and reliable answer to food problems is to achieve a high degree of self-sufficiency.

It is in this context that the role of fertilizer over the next 25 years must be assessed. Studies of agricultural growth in various countries over the past 10-15 years have indicated that fertilizer is the most important single factor in that process, accounting for 35-50% of the increases in production. As expansion of cultivated land becomes more costly and meets increasing physical constraints, and as the absolute increments of population growth in LDCs become larger, the need for gains in productivity per hectare will grow; this will call for an acceleration in the supply of fertilizers (unless substitutes can be found). As seen in Table 3, the use of fertilizers in the LDCs is far below that in the developed countries on a per capita basis. Although it has grown rapidly in postwar years, and particularly since the introduction of HYVs, it is only 6.3 kilos per capita in the LDCs compared to 18.3 kilos in developed countries in 1953 and 55.2 in 1973. If such high levels of use are economic in the U.S., Japan and Europe, then considerable gains should be possible in areas where fertilizers are still relatively unfamiliar. There is, thus, a large potential role for fertilizers in the years ahead; but if they are to accomplish the gains in productivity which will be required, a number of difficulties must be overcome.

Relative prices: Perhaps the most important issue confronting developing countries is the need to maintain a favorable relationship between fertilizer costs and foodgrain prices. Evidence obtained by comparing indices of fertilizer and foodgrain prices suggests that in several countries the benefit-cost ratio has become much less favorable, if not unfavorable, in the past two years; and certainly fertilizer use has declined in many countries, presumably partly due to farmers' price responses. If fertilizer use is to continue to expand, clearly the ratio between fertilizer and foodgrain prices should be kept in a balance that is acceptable to farmers. This is a long term as well as short term consideration for fostering the increased use of fertilizer by increasing numbers of farmers.

Distribution constraints: The use of fertilizer is frequently hampered by two types of constraint. (1) Administrative constraints, of which the most important is inadequate credit. Special regulatory arrangements, which are sometimes introduced to ensure equitable distribution of limited supplies, may be appropriate in a shortage situation; but if they carry over a "siege mentality" into a period of surplus, they may often interfere with the free flow of fertilizer through the distribution system. (2) Physical constraints, in the form of inadequate transportation and storage facilites. The demand for these has been at a premium as fertilizer use has increased, especially in those areas where high yielding varieties have been introduced, and this problem will persist as the use of fertilizer increases in the future.

Availability of appropriate supplies: Much of the fertilizer that is currently available on the world market is in the form of compounds rather than in straight fertilizers. The fertilizers produced by those plants that had been taken out of production in the middle 70's, plus those that had been available as by-products from "Caprolactam" production, were straight fertilizers such as ammonium sulphate and urea rather than the more complex compounds now being offered. Such compounds are unfamiliar to many LDCs farmers, and since they are generally tailored to the needs of temperate zone agriculture they are often inappropriate in tropical conditions. Consequently there is a need for local mixing plants to ensure that appropriate mixes are availabe in particular zones of LDC agriculture to suit the needs of their crops and climatic conditions, and for much more research to determine what those needs actually are.

Promotion of fertilizer use: Given the importance of fertilizer in foodgrain production, related as it is to increased output from high yielding varieties, there is a need to pay particular attention to the means of expanding fertilizer use. There are several dimensions of this problem: (1) The development of complementary inputs such as irrigation, and seeds, of fertilizer-responsive plant varieties; (2) Research to develop and test appropriate fertilizer and related packages, together with demonstration and extension inputs to promote farmer understanding of necessary input and management practices; (3) appropriate delivery mechanisms in terms of marketing fertilizers, and providing credit to distributors as well as to farmers; (4) the question of subsidies to promote farmers' adoption of new practices merits critical examination (see forthcoming issue of the Development Digest).

Capacity utilization of fertilizer plants: Capacity utilization varies substantially from one developing country to another. Some plants in Indonesia and in Korea, for instance, are known to have achieved over 100% capacity utilization. On the other hand, plants in many

LDCs run at 50-60% of capacity. The constraints on capacity utilization seem to be of two kinds: (1) management difficulties, and engineering design problems which affect technical efficiency; and (2) external factors such as shortage of power, variable voltage rates, delays in feedstock deliveries and similar impediments. Such problems can only be solved by a concerted effort; usually they lend themselves to administrative solutions if expansion of output is not very rapid. But if a significant and continuing growth of domestic fertilizer output in LDCs is seen as necessary, the attention to these problems becomes all the more important.

Stocking and storage. In order to ensure supplies of fertilizer to the farmer, and to take advantage of price fluctuations by building stocks when prices are lowest, it is essential that developing countries have a specific stocking and storage policy, together with the capacity for holding stocks. In many countries, such a capacity seems lacking. Where fertilizer imports have been largely left to the private sector, as well as in some others, there is often inadequate decision-making machinery at a top level to take appropriate decisions in respect of these issues. Thus, there is a need to build the administrative infrastructure and to create storage capacity in many countries. Unless this is done, farmers will be unable to count on reliable supplies where they are needed, and adoption of new practices will be retarded.

Data availability: The attainment of an effective fertilizer policy is seriously inhibited for many countries by the shortage of relevant data. In addition to uncertainty about changes on the international scene, there is frequently inadequate information on existing stocks at retail and wholesale levels and usually none on what stocks might be held beyond the farm gate. Similarly, it is often difficult to determine what proportion of orders placed in a given year are delivered by a particular date. More fundamental is a paucity of information about the farm uses of fertilizer, including imperfect knowledge on where fertilizer is used, on which crops and at what rates, what proportion of farmers use fertilizers, whether these fertilizers are purchased on credit or on a cash basis, and in particular, what the response is to the use of fertilizer in terms of units of output per unit of input. Such information is, of course, essential if there is to be any realistic demand forecasting in the short run; and for longer range planning, more data are needed for any sensible interpretaion of what implications a change in availability or price of fertilizer might have in terms of crop output, and therefore of appropriate policies. Very often, this price relationship is of primary importance, particularly when fertilizer is used primarily on foodgrains.

Developing Alternative Sources of Nutrients

Research on soil fertility has up to now been heavily oriented toward the use of chemical fertilizers. In particular, plant breeders are oriented to the promotion of a monocultural production based on chemical fertilizers. There is evidence, however, that increased rates of biological nitrogen fixation might represent a clear alternative to chemical inputs (see next article for an explanation). There has been substantial experience with this method in a few areas, and others in which experimental work has begun; but the idea is still unfamiliar to most agronomists as well as farmers. There is also some scope for developing the use of other nitrogen sources — including processed city waste and manufacturing by-products. These might be either substitutes or complements for inorganic fertilizers in the future.

While the use of city waste and factory by-products, however useful in developed countries, seem unlikely to become major sources of plant nutrients in LDCs, the potential for increased biological nitrogen fixation appears much greater. It has been taken up primarily in Australia since the early 1950s: the method was first used in the cooler southern parts of the country, where it has spread rapidly; presently the method is being successfully adapted to the sub-tropical areas further north. Elsewhere it has been tried on a large scale only in Israel so far, but proved successful there. In other countries, such as Malaysia, Kenya, Nigeria and India, the preliminary work is still in experiment stations rather than in use by farmers, but indications are that the method can be used in a wide range of temperature and rainfall conditions.

The reasons for seeking an alternative to chemical fertilizers as a source of nitrogen for increasing plant productivity are these: chemical production of nitrogen fertilizer has become more costly as the petroleum-based inputs rose in price, and these inputs seem likely to become increasingly scarce. Fertilizer presents problems of transport and storage in LDCs, especially in the tropics, because of its bulk and perishability. In addition it represents a substantial cash cost for poor or near-subsistance farmers, which limits its potential for adoption in LDCs. For these reasons, it seems possible that the leading alternative, biological nitrogen fixation, which involves little movement of materials and is low in cost to the farmer, may represent a significant method of increasing food production in a number of areas in the next 10-15 years. If the same resources were to be devoted to research on the acceleration of nitrogen fixation that went into the green revolution, the results might be even more widespread.

To summarize: population trends and physical restraints on new lands for cultivation point to a growing emphasis on increased yields from cultivated land as the main source of additional food supplies. The role of chemical fertilizers, especially in LDCs, is certainly very important. In addition, the burden of supplying an unknown but perhaps important fraction of the growing need for food supplies may be shared by nitrogen-fixing methods, as a supplement to the more familiar chemical fertilizers.

[Based on an unpublished paper presented at a Fertilizer Seminar sponsored by the Agricultural Development Council and the World Bank in Princeton, New Jersey, May 1974; updated and expanded by the author. The views expressed here are the author's, not necessarily shared by the World Bank.]

Biological Nitrogen Fixation

P. J. Dart

[Nitrogen is a basic essential for the growth of plants. Because of the high prices of nitrogen fertilizers and possible scarcity of their required inputs and the problems of moving fertilizer to many of the world's farmers, alternative methods of bringing nitrogen to plants could have a considerable importance for the increase of agricultural output. Increasing the rate of biological nitrogen fixation in crops and in the soil is a method which deserves wider recognition; its potential, and some of the associated problems and openings for research, are discussed.]

The "fixation" of nitrogen refers to a process of transformation of nitrogen from the form (N_2) in which it is found in abundance in the air and elsewhere into a combined form which can be used by plants for their growth. The fixation can be biological, as found in nature, through the action of very small organisms in the soil such as bacteria or algae; or it can be non-biological, as in the manufacture of chemical fertilizers which involves inputs of energy, usually from natural gas. This article deals with biological nitrogen fixation in tropical areas, where it has been less well studied than in temperate zones.

Despite the large and increasing use of nitrogen fertilizers in agriculture, reaching some 40 million tons in 1974, recent estimates suggest that biological nitrogen fixation contributes at least four times as much nitrogen to the soil throughout the world. Before the advent of manufactured nitrogen fertilizer, agricultural productivity had generally remained stable or increased very slightly. The soil nitrogen deficit resulting from

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the removal of produce in farming was made good mainly by biological nitrogen fixation, plus smaller amounts of nitrogen returned to the soil in manure, composted wastes, and in rainfall or irrigation water. If a nitrogen deficit persists, land productivity declines. Much of the world's agriculture continues to rely chiefly on biological nitrogen fixation.

Nodules formed on the roots of various legumes by Rhizobium bacteria are by far the best known contributor to this fixation. [Legumes are a large family of plants which includes pulses such as beans, nuts and peas (known as grain legumes), and a variety of clovers and other plants of which many are useful as forage for animals, as well as certain bushes and trees.] Other bacteria closely associated with the roots of certain non-legume plants, such as rice, sugar cane, maize, sorghum, millet and many grasses, are also important, particularly in the tropics; still other kinds of soil bacteria as well as blue-green algae, and a few non-legume plants which form nitrogen fixing nodules, also contribute.

A dramatic increase in agricultural production can result from the introduction of forage legumes, especially with application of superphosphate fertilizer, into pastures or rotational agricultural systems with relatively low fertility. In Australia, where this practice has been pushed more systematically than elsewhere, some 20 million hectares of pasture and wheat fields have been improved in this way in the last forty years; relatively little nitrogen fertilizer is used in Australia.

The increasing world demand for food and the spread of "green revolution" technology have resulted in an increase in the monoculture of cereals. One of the unfortunate side effects of this has been a decrease in many countries of the area sown to grain legumes. In India, for example, the amount of nitrogen in legume grains as a proportion of that in all crop produce declined from 24.3% in 1961-1965 to 14.8% in 1972. This is unfortunate, not only because legume grains are a nutritionally valuable source of protein for humans, but also because they contribute to the maintenance of soil fertility with minimum fertilizer increases; and as supplies of the required energy inputs for nitrogen fertilizer become scarcer or more difficult for particular countries to obtain, the value of nitrogen fixed in the soil by legumes increases.

Potential for Legume Uses.

The amounts of nitrogen fixed, and the quantities of dry matter and/or grain they produce, vary widely between types of legumes, and also between the regions where they have been tested. This wide range suggests that yields can be improved; much of the variability reflects differences in husbandry. Estimates of nitrogen fixation are nearly

all derived indirectly. In short term experiments it is difficult to measure changes in soil nitrogen by chemical means, so the contribution of soil nitrogen to the plant is estimated by the uptake of nitrogen by a non-nitrogen fixing crop grown at the same time. The difference between nitrogen contents of the two types of plants gives an estimate of nitrogen fixed. (The recent development of a more sensitive measure of nitrogen fixation is described below.)

Table 1: Estimates of Quantities and Values of Nitrogen Fixation in the Field by some Principal Legumes

Plant	Quantity of N fixed in a growing season (Kg per hectare)[a]	Value as fertilizer of N fixed ($ per hectare)[b]
Lucerne (Alfalfa)	50-460	15-138
Clovers	50-670	15-200
Other Temperate Pasture Legumes	20-200	6-60
Tropical Pasture Legumes	20-400	6-120
Peas	30-140	9-42
Chickpeas	100	30
Soybeans	40-200	12-60
Peanuts	70-240	21-72

a. Ranges of values in recent findings; due to the complexities of the factors involved these ranges are wide, with extreme values in both directions relatively unusual.

b. The nitrogen fixed was valued conservatively at a 1975 "farm gate" cost of $0.30 per kilogram of N.

The above estimates have generally been made with plants grown in temperate areas rather than in the tropics. Estimates have also been made from plants grown in pots, but these usually give unrealistically high values for the field situation. Such experiments, however, have shown that the levels of nitrogen fixation by grain and forage legume of the tropical varieties can be as high and often higher than those for temperate legumes. Tropical forage legumes have been found to fix considerable amounts in the field — up to 400kg N/ha/annum for established stands in Hawaii. Perhaps more remarkable is the estimate 200 kg N/ha fixed in the 3 months from establishment for Crotolaria sp.

on savannah soils near Ibadan, Nigeria. Browse trees such as Leucaena leucocephala are also very active nitrogen fixers (up to 580 kg N/ha/annum).

Very high grain yields can be obtained from grain legumes in the tropics under controlled conditions in experiment stations: e. g., up to 2,600 kg/ha for cowpeas at IITA, Nigeria; up to 4,000 kg/ha for soybeans at IITA and in Costa Rica; and 4,000 kg/ha for groundnut kernels at Samaru, Nigeria; and 3,000 kg/ha for chickpeas in India (IITA: the International Institute of Tropical Agriculture). Maturity can be reached for such crops in less than 120 days. Experiments with cowpeas, soybeans, and groundnuts indicate that the nodule system can fix enough nitrogen to cope with the large amounts such high yields require, and that little or no yield increase is obtained by heavy nitrogen fertilizing. Thus the tropical climate per se does not impose any restriction on nitrogen fixation or the yields of adapted species and varieties, and there is scope for considerable improvement in average yields in the field.

Not all the nitrogen fixed by legumes finds its way to their grain; groundnut haulms for example are a valuable byproduct providing high quality animal feed. If the plant residues are returned to the soil, or to a lesser extent even if they are burnt, they supplement the fixed nitrogen of the roots in building up soil nitrogen. Not much is known with precision of the quantities of nitrogen involved; but it is well established that if legumes are planted in rotation with cereals, this nitrogen can substantially benefit the cereal yields (even if the cereal also receives nitrogen fertilizer). In a field experiment in Northern Nigeria, maize yielded more following a single groundnut crop than after N-fertilized cotton or sorghum; maize yields with no nitrogen fertilizer additions were 44% greater after groundnuts (3,400 kg/ha) than after the sorghum (2,390 kg/ha). Grain yields should be thought of in terms of the whole agricultural system. Perhaps desirable legume plants which would have lower grain yields but with commensurately greater potential for enriching soil fertility and increasing cereal grain yields might be the plant type to seek.

Factors limiting legume yields. Given the desirability of increased cultivation of legumes, it is important to find ways of increasing their yield of useful products. Many of the legumes currently used in agriculture have a higher phosphorus requirement than other crops. Some tropical soils are very low in available phosphorus, and economic responses may be obtained from fertilizing with superphosphate. Two relatively new areas of research point to ways of reducing the cost of providing adequate phosphorus nutrition. Legumes, like many other agricultural plants, form endotrophic mycorrhiza on their roots, mainly with the fungus Endogone. The fungal hyphae extending from the root surface in effect enable the root to explore

more soil and thus exploit more of the readily soluble phosphorus pool, thereby increasing the plant uptake. Inoculating soybean seedlings with Endogone, for example, can dramatically increase plant growth, and hence nitrogen fixation, in tropical soils low in phosphorus not containing the fungus.

Another way to increase the availability in subtropical conditions to legumes of phosphorus from rock phosphate by adding sulphur was developed independently in Northern Nigeria and in Australia. In Nigeria, Togolese rock phosphate (37% P_2O_5) was mixed with 10% of elemental sulphur in a concrete mixer, giving a ratio of P:S of 1:0.7. Applied at 158 kg/ha this mixture gave significantly greater grain yields (1,580 kg/ha) of groundnuts at one site than superphosphate in the first year of application, and a 55% increase in total dry matter over rock phosphate alone. The economics of production of such a fertilizer seem more favorable for many countries than for superphosphate which provides the same nutrients.

Increasing the rate of nitrogen fixation in legumes. Nodulation and nitrogen fixation depends on the presence of the appropriate strains of Rhizobium in the soil. The right strains to form effective nodules, which fix nitrogen, may be present in low numbers, or absent from soils where the particular legume has not been grown. In Africa, for example, effective strains of Rhizobium for soybean are often lacking. Even where the appropriate rhizobia are present their numbers may decline when legumes are not grown, and perhaps also decline in hot dry seasons. For many tropical legumes research is needed to determine which species or strains of rhizobia will best nodulate them. The distribution of different Rhizobium strains in soils can vary, and these populations may also change as the legume grown selects particular strains to form its nodules. More research on the dynamics of Rhizobium populations in tropical soils would be valuable.

The absence of appropriate rhizobia from soils can be overcome by inoculating the seed, that is, by adding prepared cultures of the right kind of bacteria to the seeds before planting. In Australia this has become so widespread that some 20 factories have been selling pellets containing rhizobia appropriate for particular localities to farmers who mix them with their seeds. It is important in developing the inoculation service in new areas that good, stable rhizobia strains are used in inoculants, and that good quality inoculants containing high numbers of rhizobia are used. Experience to date indicates that the problems of finding appropriate rhizobia for new areas and producing inoculants are soluble within five years, and in time more rapidly as the technology becomes more widely understood. This has been shown when the inoculation method was extended from the temperate zones of Australia where it was first used to quite different subtropical zones of that country, and also by its successful use in Israel, and on a small scale in Kenya and elsewhere. It should be emphasized that

all this experience has involved profitable use by farmers, not just results in experiment stations.

Nodulation of some legumes is inhibited by soil acidity; tropical legumes vary in their sensitivity. Prodigious amounts of lime may be needed to reduce soil acidity in some areas and high transport costs will frequently rule out such a solution, so that productive use of such soils requires tolerant plant species and varieties. Current research suggests, however, that this will be possible for both grain and forage legumes. Nitrogen fixation by legumes also requires a higher level of molybdenum than growth with other forms of nitrogen. Molybdenum deficiency is often associated with deficiencies of other trace nutrients such as zinc, copper and, more occasionally, boron. Nitrogen fixation and plant growth respond markedly to small applications (up to 10 kg/ha) to overcome these deficiencies. Molybdenum sprayed onto groundnuts in Northern Nigeria, and on Phaseolus vulgaris beans in Brazil in conjunction with lime, gave marked increases in yield.

Nitrogen fixation by nodules, and legume yields, are also influenced by environmental factors such as soil temperature, water availability, light intensity and day length. Pot experiments show that the high soil temperatures often reached in tropical soils can limit nodule formation and subsequent nitrogen fixation in cowpea, soybean and chickpea. Soil temperatures are significantly reduced by mulching and plant cover. Some of the Rhizobium strains nodulating Cicer arietinum, Vigna mungo and V. radiata, and soybean are much better adapted to high soil temperatures than others, and this should be taken into account in strain selection for inoculants.

Many tropical legume species are photoperiodically sensitive, and daylength differences can be critical for their development and flowering. As daylengths shorten, and light intensities decrease, nodulation and nitrogen fixation by cowpeas, soybean and Phaseolus vulgaris also decrease. It is a moot point whether plant breeders should develop varieties adapted for a particular region, or should aim for more universal but possibly lower yielding varieties. One of the surprising results from experiments with soybeans at IITA, Nigeria, is that good nitrogen fixation and yields can be obtained with varieties normally grown in the northern United States; thus, some legume varieties seem adapted to a wide range of environmental conditions.

Recent experiments at Rothamsted, England, with Vigna mungo, V. radiata, cowpea, pigeon pea and Phaseolus vulgaris have shown that the presence of organic matter in the vicinity of their roots stimulates their growth and nitrogen fixation. In a sandy soil with different levels of organic matter induced by treatments over several years, nitrogen fixation by V. mungo and V. radiata was much influenced by both the level and form of organic matter present. This points to the

desirability of turning plant residues into the soil.

Nitrogen Fixation Associated with Non-Nodulated Plants

Up to this point the discussion has focussed on nitrogen fixation by organisms which live in nodules on legume plants; but there are other possibilities. An important technical advance in measuring nitrogen fixing activity was the development since 1960 of the acetylene reduction assay — a new method of measurement which has made possible an exploration of these other forms of nitrogen fixation. The enzyme (or protein catalyst) "nitrogenase," which converts nitrogen gas to ammonia, also converts acetylene to ethylene at rates which are comparable to nitrogen fixation. Acetylene and ethylene concentrations can be readily measured by gas chromatography, with a sensitivity that is about one thousand-fold better than for chemical analyses of nitrogen. In the assay about 10% by volume of acetylene gas is added to the soil or plant sample enclosed in a gas-tight container; after a suitable time period the atmosphere is sampled, and the amount of acetylene converted to ethylene determined. The equipment needed, apart from the gas chromatograph, is inexpensive. This assay is now widely used for studying many types of nitrogen fixing systems; methods for studying field-grown plants with large root systems such as sorghum are still being developed. Measuring nitrogen fixation by chemical analyses of soil becomes unreliable at rates of accumulation less than about 100kg N/ha/annum for short-term experiments, and this insensitivity was probably the main reason why the level of nitrogen fixation by non-nodulated plants has been difficult to estimate reliably, and why its importance was underestimated.

Measurements of soil nitrogen have shown that some temperate ecosystems lacking nodulated plants can accumulate substantial amounts of nitrogen from biological fixation. The Broadbalk experiment at Rothamsted, England, is perhaps the best documented example. On land first sown to wheat in 1843 and more or less continuously cropped with wheat since, nitrogen balances show a steady gain of 34 kg N/ha/annum on plots receiving no nitrogen fertilizer; most of this gain is contributed by nitrogen fixation. Leguminous weeds have played some part in this, but recent assays of soil nitrogen fixation showed that blue-green algae crusts on the soil surface contribute the major part of this nitrogen. No significant nitrogen fixing activity was found in the soil below the surface, or associated with the wheat roots. The activity was positively correlated with soil moisture levels.

Rice has been cultivated more or less continuously in parts of Asia for perhaps thousands of years without the benefit of nitrogen fertilizers. The soils remain relatively fertile when inputs of nitrogen from

irrigation water or in rainfall are low, implying that biological nitrogen fixation by bacteria associated with rice roots maintains the soil nitrogen levels. In addition, blue-green algae are often plentiful in the paddy water, and on the soil surface when the water level is lowered, and they also live in the tissues of the small aquatic fern Azolla which floats on the water surface and then grows on the soil surface. These algae fix nitrogen, possibly as much as 60 kg/ha/season. In India and Japan several experiments have shown yield increases for rice when the water is inoculated with blue-green algae, with or without addition of nitrogen fertilizer. The response is probably partly due to the nitrogen fixation and partly to growth hormone production by the algae. Inoculations with these algae can yield economic returns in India at the moment.

Many tropical grasses from three continents have also been found to have substantial amounts of nitrogen fixation associated with their roots, and for some this seems almost enough to satisfy their nitrogen requirements. Assays have shown activities greater than 1 kg N/ha/day for Pennisetum purpureum in the field in Brazil. The bacteria involved are closely bound to the root surface and perhaps in the root tissues. Although nitrogen fixing bacteria are present in soil more distant from the roots, they do not have any activity until a carbohydrate source is added by the grasses. Cultivars of some grasses differ markedly in their nitrogen fixing activity, so that there is a major role for plant breeding to enhance this activity.

As well as the grasses, sugar cane, sorghum, millet and maize also have some root-associated nitrogen fixation. A few field experiments have shown little response to nitrogen and low recoveries of added fertilizer for these plants, suggesting that nitrogen fixation can sometimes play the important role in the crop's growth. Use of cultivars which actively stimulate this activity could have an important role in reducing nitrogen fertilizer requirements. All these examples of fixation by "associative symbiosis" point to relatively new areas for research which may become highly rewarding.

Utilization of Nitrogen Fixing Plants in Farming

If biological nitrogen fixation is to be increased, then changes in the present agricultural systems will be necessary. Sowing greater areas of legumes will have the greatest and most immediate impact. Introducing rotations involving grain legumes will be important and will also help to reduce the potential dangers from pests and diseases that are inherent in monoculture of cereals over large areas. The incentive for making these changes would be considerably increased if as much consideration were given to the encouragement of production

of grain legumes in government pricing policies as is currently given to cereals. Efforts to increase the use of phosphate fertilizer by subsidies and by development of the infrastructure to enable their widespread distribution to areas of phosphorus deficiency could also help increase nitrogen fixation and yields.

Where enough land is available, and there are no restrictions on the use of grazing animals (either cultural or ecological), soil fertility is most easily, cheaply and quickly built up by a mixed agricultural system with legume-based pastures alternating with cereal and/or other cash crop production. Introducing legumes into tropical pastures dominated by grasses markedly increases the utilization and digestibility of the latter, giving a relatively greater increase in animal production than the increases in plant growth. Cereals subsequently grown in these pastures need little or no nitrogenous fertilizer for good yields. In the Murrumbidgee Irrigation Area in Australia the combination of low incidence of diseases and pests, and cropping after clover-grass pasture, produces the highest rice yields in the world — around 9000 kg/ha — with no fertilizer addition.

Increasing the incidence of legumes in tropical bush fallow systems will help to reduce the fallow period, possibly to as little as one season. Vigorous climbing legumes such as Pueraria phaseoloides can compete with the bush species and have potential fixation of the order of 150-200 kg/ha in four months. The legume would be undersown in the crop normally preceding the fallow. Obviously the greatest benefit from such a fallow would accrue from turning in the green stuff if suitable, inexpensive methods for doing this could be devised. There are also preliminary indications from experiments at Moor Plantation in Ibadan, Nigeria, that if the burning of crop residues is done in the "dry" season when the legume has died back, then most of the nitrogen fixed is left in the soil. Little is known as yet of the amounts of nitrogen (and sulphur) lost from the burning used in many agricultural systems; such losses may be low and, if so, burning may be a suitable alternative to plowing crop residues into the soil.

Greater use can also be made of legumes by intercropping. Farmers in many countries traditionally intercrop two or more species, one of which is often, but not invariably, a legume. Yields are not necessarily decreased, as intercropping often produces a greater leaf area index for planted crops, less weeds develop, and the distance between the main crop plants — often sorghum or millet — usually remains the same as when they are sown as a sole crop. Where water is not limiting, intercropping is a built-in insurance against total loss of yield. It may be possible to introduce a quick-growing annual, forage type of legume as an undersown cover crop to increase nitrogen fixation. Where there are no livestock to consume this forage the benefits will not accrue until a subsequent season and hence it will be difficult to persuade

farmers to adopt; so it will probably be easier, in such cases, to introduce a grain legume that may have a low grain yield but will incorporate a good deal of fixed nitrogen in parts of the crop turned in at the end of the season. Any nitrogen fertilizer applied to plants in an intercropping system will need careful placement so that the nitrogen fixation by the legume is not reduced. Intercropping requires more labor, but this can usually be spread by staggered plantings. Increased input of labor can increase production as well as reduce rural underemployment and drift of population to the cities in areas of surplus labor.

A variation on the intercropping principle is the multiple cropping system using shorter season, sole crops, and under-sowing of the next crop. Such systems alternating grain legumes with rice are currently being explored at IRRI (The International Rice Research Institute) in the Philippines. In Bangladesh farmers often follow rice with peas, lentils or chickpea, and jute with Vigna radiata and V. mungo to use the residual soil moisture. Legumes sown at the end of monsoon period, which can survive into the dry season, will fix some nitrogen and can provide good nutrition for stock when dried off.

In addition, nitrogen fixation may be combined with livestock feed from bushes and trees. Shrubby trees such as Leucaena leucocephala fix much nitrogen, are drought resistant, and provide dry season feed. The potential of leguminous trees to provide stock feed from the foliage, and human food from the fruits and seeds, has been little explored.

In sum: there are some 12,000 species of legumes ranging from tropical forest trees to annual herbs. Much can be done to increase nitrogen fixation by making greater use of the potential such diversity offers. The introduction of non-indigenous plants into new areas has enormous potential for legumes. When the normal diseases and pests are left behind, the introduced grain and pasture legumes can give yields greater than indigenous plants. Australia's native pasture legumes generally yield poorly, and the introduction and breeding of better adapted legumes (e. g. subterranean clover, Townsville lucerne, Siratro) was the basis for successful pasture improvement. More generally, the Australian experience demonstrates that increasing the productivity of many types of land by reliance on biological nitrogen fixation rather than nitrogen fertilizer is a practical possibility on a very large scale. Further, the Australian development in the 1950s of the method for inoculating legume seeds with rhizobium bacteria has shown practical results which suggest possibilities for use elsewhere. There are thus useful applications with present knowledge, as well as many areas in which research could produce significant

results for application in tropical agriculture over the next ten years.

[Adapted from an unpublished paper presented to the eighth meeting of the Technical Advisory Committee to the Consultative Group on International Agricultural Research; World Bank, Washington, D. C., July-August 1974.]

Note: For readers who may wish to explore more deeply the scientific aspects of nitrogen fixation, the following references can supply a wider orientation and introduction to the literature.

1. J. M. Vincent, "Nitrogen from Microbes," The Journal of the Australian Institute of Agricultural Science, December 1972, pp. 236-249. A summary of the evolution of knowledge about nitrogen fixation, including a survey of Australian experience.

2. R. F. W. Hardy and U. D. Havelka, "Nitrogen Fixation Research: A Key to World Food?," Science, Vol. 188, No. 4188, May 9, 1975, pp. 633-643. A more comprehensive exposition of numerous biological and chemical findings and questions arising in current research.

Sewage Farming

Jonathan Allen

[The use of sewage as a source of fertilizer has attracted new interest in recent years. There are various ways in which this can be done; the method described here is the most commonly used to date.]

Discharges from sewage treatment plants have been used to irrigate crops in a number of areas of the world, including Europe and the British Isles. The benefits have included reduced water pollution, better crops, and increased utilization of scarce water and fertilizer resources. Under proper management, this method of recycling wastes has not presented a health problem. Of course this is not a new idea. Human wastes have been collected and used for crop fertilization for centuries in the Orient. Some European cities have operated sewage farms for many years. Edinburgh, Scotland is reported to have had one as far back as the middle of the eighteenth century. The most extensive and successful operations, such as the Berlin and Paris sewage farms, were begun around 1850. By 1931, the Berlin sewage farms were supplying one-fourth of the produce and the pasturage for the dairy herd that produced one-sixth of the milk consumed by the city's 4.8 million inhabitants. Perhaps the most sophisticated system was that at Wassmannsdorf, Germany, where, about 1930, sewage was treated in an anaerobic digester before both the liquid effluent and the sludge were distributed to the farms. The methane from the digester was used to power gas engines to run the pumps.

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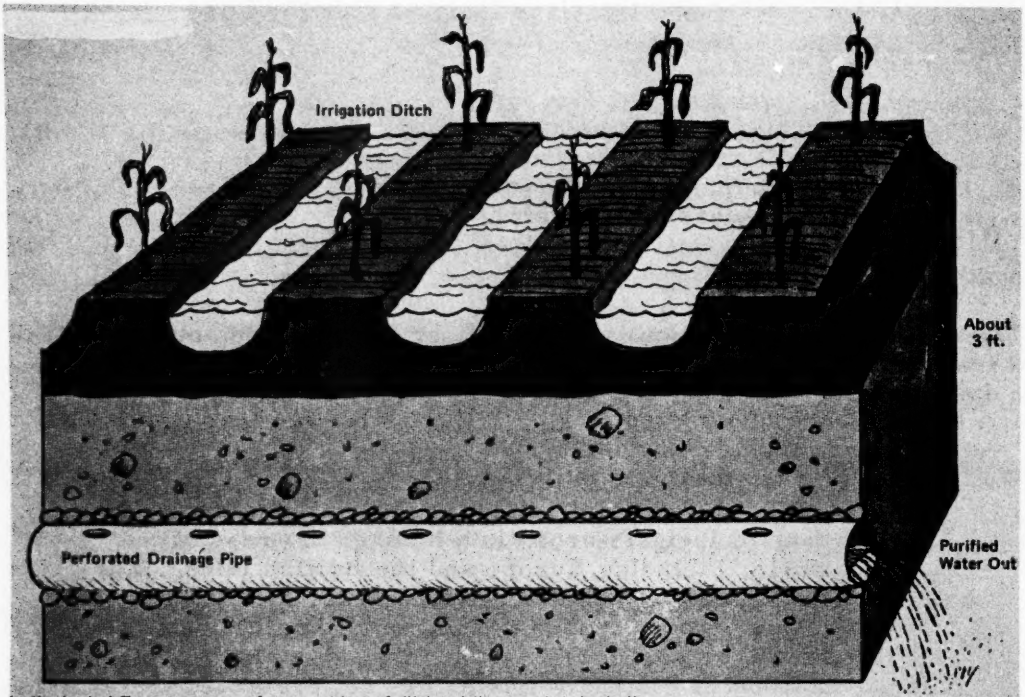

In the typical European sewage farm, a system of ditches delivers wastewater to the crops. After percolating through the "living filter" of the soil, the water is collected by a network of drainage pipes or tiles and returned to the waterway.

Most recently, Israel has been using sewage irrigation, not so much to dispose of waste effluents as to make maximal use of the country's extremely limited freshwater resources. Thus the sewage of Tel Aviv, instead of polluting the beaches of the Mediterranean Sea, is being used to grow fruits and vegetables in the Negev Desert. The desert is otherwise too arid to support any vegetation other than a few strands of grass.

In the U. S., sewage effluent was used for crop irrigation only on a small-scale basis in the late nineteenth and early twentieth centuries, and until recently the approach seemed virtually to have been forgotten. During the past fifteen years, however, agronomists, ecologists, and others are discovering this wonderful "new way" of irrigating crops, renovating wastewater, recharging the groundwater, disposing of sewage, and saving fertilizers. The most comprehensive and best controlled experiment in sewage irrigation in this country is the Waste Water Renovation and Conservation Project of Pennsylvania State University. The Penn State plots irrigated with sewage effluent produced, in every case, a greater growth of crops than did the control plots fertilized in the conventional manner but dependent on rainfall for water. The ratio was often two-to-one. Plots both fertilized and irrigated conventionally yielded as well as did the

sewage effluent plots. Other large scale projects have been undertaken in Chicago, Denver, and elsewhere.

Limitations

Despite success in the Pennsylvania study and in projects abroad, there are definite limits to the circumstances under which sewage farming is practical and ecologically sound. First of all, sewage irrigation can only be conducted successfully on soil sufficiently permeable to absorb both irrigation effluent and naturally occurring precipitation. If the rate of application of water to the land is so great that sustained ponding, or even continuous saturation of the topsoil, occurs, then anaerobic soil conditions will certainly follow.

With any irrigation technique, there also is the danger of a buildup of salts in the land. Most sewage has a salinity about 30 percent greater than that of the municipal water supply from which it in large part originated. Yet Heukelekian, in describing sewage irrigation in the arid parts of Israel, minimizes the salt problem. First, reduction of crop growth which might result from salinity is more than made up for by the abundance of nutrients which promote growth. In addition, rainfall leaches out accumulated salts so that long-term buildup is not a problem. The difference between the conclusions of the American and Israeli experiences no doubt stems from the difference in application of wastewater. In Israel the maximum annual irrigation never exceeds about 45 inches, whereas typical irrigation in the U. S. is more in the neighborhood of 100 to 200 inches for sewage effluent farming.

Perhaps more detrimental than salts is the possible accumulation of heavy metals or of refractory industrial wastes. Heavy metals such as mercury, lead, copper, and zinc tend to be concentrated by soil organisms and then assimilated by crops. Copper and zinc may poison the plants themselves; mercury and lead may render the crops unfit for human consumption. G. Rohde reported in 1962 that after more than 100 years of sewage farm operation at high rates of application, some of the soil at both the Paris and Berlin farms had been showing markedly decreased productivity. Chemical analysis of both the "exhausted" soil and nearby productive soils showed the cause to be an accumulation of copper and zinc. The metal boron presents a special problem. It is toxic to plants in concentrations of 0. 33 to 3. 75 parts per million, depending on the sensitivity of the species. Yet, boron in the form of borax is a common ingredient in commercial detergents and may thus be present in hazardous concentrations in sewage.

All of these problems lead to the conclusion that if wastewater is used for agriculture, communities may have to guard their sewers

against contamination as zealously as they now guard their reservoirs. It may be necessary to require that industries handling certain materials either have separate sewerage (except for sanitary wastes) or else complete private treatment facilities to remove toxic matter before the sewage is discharged into the municipal system. If boron proves to be a problem, its use in detergents will have to be banned in any community in which wastewater is used for irrigation.

One fear which people have with regard to crops grown in sewage effluent is that of disease. Does the irrigation of a crop with sewage effluent necessarily present a disease hazard, either to those who work in the fields or to those who consume the produce? All authorities agree that the transmission of pathogens can be prevented, but their opinions vary as to the degree of caution necessary to insure complete safety. There are, however, some encouraging facts. First, pathogens do not survive well in the soil; almost all die within two weeks. Second, pathogens do not survive being cooked. In addition, there is no evidence that germs can be assimilated by the plants through their root system and thereby contaminate the fruit. Furthermore, in all the years of operation of the European sewage farms, many of which were before the use of modern vaccines, there have been no abnormal outbreaks of disease either among the workers on the farms or among the people who have eaten the produce. However, sewage effluent should not be used to irrigate vegetables that are eaten raw or that grow on, or very near, the ground. If wastewater spray irrigation is used on fruit trees, it should be stopped at least four to six weeks before the harvest.

The Israeli Ministry of Health has published the following list of crops that may be raised with primary treated sewage: beets for sugar and stock feed, pasture and hay, vegetables that are always cooked before eating, and also apples, pears, and plums if irrigation is stopped at least one month before harvest. Tomatoes are permitted if they are destined to be canned. Those crops which are not eaten at all, such as cotton and other fibers, ornamental plants, plants grown for seed, and trees for lumber, pulp, and landscaping can be added to the list.

Another significant limitation is that the sewage is delivered to the treatment plant at a rate quite independent of the irrigation needs of the crops. In fact, where the sewer system includes storm drains, the maximum flow into the plant will coincide with maximum rainfall when crops don't need irrigating water. Furthermore, in northerly climates, disposal in the winter may present a problem. The Berlin sewage farms include a large area of unclutivated land just for the disposal of surplus wastewater which exceeds the capacity of the farm proper. The recent Pennsylvania experiment included a sizeable

acreage of forest and shrubland that was used in the winter in place of cropland. This arrangement was reported to produce satisfactory results. In the winter there was often a large accumulation of ice near the sprinkler discharges, but it melted gradually, and the water was absorbed by the soil.

Cost comparisons. This author was unable to find any truly complete and satisfactory economic analysis, and it is doubtful that such a study exists. The nearest approximation is a 1972 study of the Chicago area by the U. S. Army Corps of Engineers. Three alternative treatment systems and appropriate sewer networks were assessed for the 2,500-square mile Chicago-Northwest Indiana region which contains 13,500 industries and is predicted to have nine million people living there by 1990. The alternative systems were investigated at different assumed operating loads; the largest system considered would involve, by 1990, the treatment of 3.3 billion gallons per day of municipal, industrial, stormwater, and agricultural wastes. Cost estimates for the three alternative methods of sewage disposal, expressed in 1972 dollars per capita of assumed population, were as follows: for advanced biological treatment — $81.00; for physical-chemical treatment — $74.80; for use on land after primary treatment — $47.10. The last is by far the lowest, even without making farmers pay for the effluent — which could offset a portion of the cost.

The most successful sewage farming is possible when the emphasis is on the farming rather than the sewage. That is, the wastewater from sewage should be thought of as a precious resource to be applied as needed to fertilize and irrigate the land, even if it is necessary to pipe it for considerable distances. A maximum application of 50 inches per year means that one acre will be irrigated for each 1.3 million gallons of sewage annually. Thus if we assume a sewage production of 80 gallons per person per day, a community would irrigate 22 acres for every thousand inhabitants; a city of 100,000 would support a sewage farm of 2,200 acres. In arid regions or humid regions, the amount of farm land serviced would vary inversely with the water requirements of the soil.

The treatment of sewage could be minimized; the first stage of primary treatment would be sufficient for agricultural uses, thus avoiding the costly secondary treatments which are needed to prevent pollution of the areas of sewage disposal. Crop selection would have to be based not only on the usual criteria of soil, climate, and market, but also on suitability for sewage farming techniques. In many instances the ratio of nitrate to phosphate in sewage is higher than that demanded by plants; thus it would be advisable either to select crops with relatively high capacity to assimilate nitrates, or to add the phosphates separately. Finally, in most operations it will be necessary to have either storage ponds, or "ballast land" such as forest,

in which short-term water demand is not critical, to compensate for temporary discrepancies between sewage effluent output and irrigation demands. Most of these problems can be solved by available technological methods.

[Extracted form "Sewage Farming," Environment, Vol. 15, No. 3, April 1973, pp. 36-41. St. Louis, Missouri: Scientists' Institute for Public Information, Copyright©, Scientists' Institute for Public Administration.]

Editorial Comment: Other ways in which sewage may be used for farming include the manufacture of organic fertilizer from sewage sludge; the city of Milwaukee, for example, sells an odor-free granular product, Milorganite, which has a six percent nitrogen and two percent phosphate content. But these are not high percentages compared to chemical fertilizers, and it is not cheaper to produce; six percent nitrogen is probably a maximum, not available in most city wastes. Another method, still largely experimental, is the use of sewage sludge, after various levels of treatment, for mixing into sandy or otherwise unpromising soils, which may have under some conditions more lasting benefits than additions of chemical fertilizers due to its biological contents.

One may conclude that none of these methods could readily replace chemical fertilizers as a major source of plant nutrients in developing countries. For urbanized countries where sewage collection systems are operating, one or more of these methods can be of interest as a means of economical, non-polluting waste disposal with a fertilizing byproduct. But they do not appear to offer more than a limited solution to the problem of developing a substantial supply of plant nutrients.

Author's Reply: Sewage irrigation demands little sophisticated technology, is economical on a small scale, and is thus well suited to small communities. Even if a village presently lacks central sewerage, we ought not to rule out sewage farming entirely without comparing the cost — both short and long run — of installing a system for that explicit purpose with the cost of perpetually buying and applying chemical fertilizer.

The International Fertilizer Development Center

Donald L. McCune

[An International Fertilizer Development Center (IFDC) was founded in October, 1974. It is to be a major world research institution, giving attention to all aspects of the production and use of chemical fertilizers — scientific, agronomic, marketing — with special attention to their use in the tropics. IFDC's proposed program of work is outlined.]

The IFDC is the first of the international centers for agricultural research which is not located in a developing country. The decision to place it close to the existing U. S. national center for fertilizer research operated by the Tennessee Valley Authority (TVA) in Muscle Shoals, Alabama, was made because that center had already developed a combination of physical facilities and expert personnel unique in the world. The unexcelled collection of materials in the TVA library with its sophisticated computer system for search and retrieval could be shared with IFDC, as could TVA's specialized laboratories and pilot plants. Duplication of such equipment and buildings elsewhere would have cost $200-300 million. Also, access to TVA staff with their experience and know-how in fertilizer technology will permit the IFDC program to proceed at an accelerated pace.

The funds for IFDC have come from the U. S. Agency for International Development and the Canadian International Development Research Center. As its work expands, funding from other international sources is hoped for. The IFDC looks forward to close contact

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with the World Bank-centered Consultative Group on International Agricultural Research (CGIAR – which coordinates programs and finance for the nine major international centers such as IRRI in the Philippines and IITA in Nigeria), and eventually full acceptance within the CGIAR network.

Background: Importance of the Tropics

With world population increasing at a rate of 70 to 75 million per year, the race to prevent widespread famine continues. Fortunately this race can be won, but only if our knowledge of the potential for food production in the tropics and subtropics is adequately increased, and in time. More than 50 percent of the potentially arable land lies within the tropics. This amounts to over 4 billion acres. Another 4 billion acres, or nearly half of the potentially grazable land, is also found in the tropics.

Table 1. Arable and Grazable Lands of the World

	Potentially Arable		Potentially Grazable	
	Billion Acres	%	Billion Acres	%
Polar and Subpolar	0.00	0.00	0.00	0.00
Cold Temperate Boreal	0.12	1.53	0.47	4.66
Cool Temperate	2.24	28.50	2.46	27.27
Warm Temperate and Subtropical	1.37	17.43	2.08	23.06
Tropical	4.13	52.50	4.02	44.57
Total	7.86		9.03	

Source: President's Science Advisory Committee, Report of the Panel on World Food Supply, May 1967

The fact that the temperature and often other climatic factors favor long growing seasons or year-round agriculture further magnifies the potential for agriculture in the tropics. To date, only a fraction of this potential is being tapped. Large parts of Africa and Latin American plus sizeable portions of Asia, especially in Indonesia and the Philippines, are not yet cultivated. But it is increasingly costly to bring new land into production and to market output. Higher yields are needed to make this feasible. Those areas that are cultivated are producing only a fraction of their potential. More land must continuously be brought into production; but increasing crop yields per unit of cultivated land must be the major source of future increases.

Even though the climate and soils of sizeable tropical areas are known to be conducive to highly productive agriculture, the soil and

other ecological characteristics are such that, once these soils are brought under cultivation, crop production can flourish for only a few years unless the native soil fertility is replenished. Shifting agriculture, including various systems of slash and burn, has been practiced as the best available alternative with traditional crops and low population density. With rapid population growth and other factors making this system less and less practicable, and with the necessity of much higher yields per acre, more and more traditional practices must now be replaced with continuous cropping systems that are efficient under the various conditions found in less developed countries (LDCs). Yields need to be at least doubled by the end of the century. This requires major improvements in plant nutrition. To achieve this, fertilizers must play an extremely important role — a role even greater than they play in temperate agriculture. Other means of improving plant nutrition need concerted attention, but it is generally agreed that a large part of the task will have to be done by application of chemical fertilizers. In many cases applied fertilizers must supply one or more plant nutrients that are inherently deficient in the tropics. They must also supply and replace the nutrients removed by the crop, leached out by rain, or washed away as soils erode during unwise exploitation. Only with adequate plant nutrients can the potential of the tropics and subtropics be achieved. Where essential elements are lacking or in short supply, food production cannot adequately supply even minimum human needs.

Attempts have been and are being made to utilize and transfer existing technology and know-how in fertilizers to the LDCs. This has met with some success. Where climate, crops and soils are similar to those of the developed countries, present fertilizer technology appears to be adequate with some adaptations — from a technical production point of view, although the socio-economic circumstances in LDC production may call for major changes. For the bulk of the tropics and subtropics, however, where climate, crops and soils differ markedly from those of the developed countries, present day technology and fertilizer materials are often inadequate even from the technical viewpoint.

All fertilizers currently available in the world have been developed in temperate zones for use on temperate zone soils and crops. For the most part marketing techniques as well as production, transportation, handling and storage techniques used by the developing countries are also adaptations of what has been successful in temperate zone agriculture. New technology is needed if the tropics and subtropics are to play their proper role in producing the world's food supply in years to come. Whatever the maximum potential may be for international trade in food, it is recognized that the developing countries must raise most of their own food. Without improved fertilizers and fertilization practices for LDC conditions, it is doubtful if this

goal is attainable. Thus far no concerted effort has been made to close this gap.

Research and Development at the IFDC

Research and development efforts will eventually cover many aspects of fertilizer production, marketing, and use. Initial effort will be concentrated on problems for which there are promising prospects of early solutions; some support will also be given to longer range R & D efforts where major breakthroughs seem probable. Early R & D of the IFDC will include but not necessarily be limited to the following.

A. Improving the Efficiency of Applied Nutrients

The objective is to maximize uptake of nutrients by crops, and to minimize losses through leaching and volatilization or tie-up in unavailable forms in the soil. 1. Controlled Release. Through design of fertilizers to obtain release patterns for fertilizers in the soil that generally parallel the uptake patterns of specific crops. Various mechanisms or combinations of mechanisms will be used to attain fertilizer release rates in the soils similar to crop uptake patterns determined by agronomists to be typical of crops in certain geographical areas. Sulfur-coated products (urea, potassium chloride and complete fertilizers) will be a successful starting point from which to build. Primary emphasis will be on the nitrogen component of fertilizers, with secondary emphasis on other leachable nutrients such as potassium and sulfur. 2. Reducing soil tie-up of nutrients. Plant uptake of applied nutrients, especially phosphates, is often quite low due to reactions in the soil that rapidly convert nutrients into forms unavailable to plants. Through better understanding of the mechanisms that are responsible for such tie-up, corrections either as soil amendments (e. g. silicon or liming materials), through fertilizers that combat rapid tie-up but are still available to plants, and the use of cropping systems which maximize utilization of soil nutrients and which return organic matter to the soil, will be sought, developed and introduced.

B. Expansion and Better Use of Raw Materials that Furnish Fertilizer Nutrients

The objective is to develop techniques that permit the use of additional and indigenous resources for fertilizers. Although fertilizer nutrients occur in abundance in nature, their exploitation is severely limited by their uneven distributions over the earth and the constraints of the technologies available for transforming these elements into utilizable fertilizer forms.

Elemental nitrogen makes up nearly four-fifths of the earth's atmosphere. The nitrogen from the air must first be "fixed" into forms available to crops. Ammonia (NH_3) is the basic building block of all common synthetic nitrogen fertilizers. The key to fixing nitrogen for use by crops is hydrogen; under high temperature and pressure, hydrogen and nitrogen can be reacted to form ammonia. Over 90 percent of all nitrogen fertilizers depend on natural gas or petroleum derivatives for the source of hydrogen. Hydrogen can also be obtained from coal or by electrolysis of water but usually at greatly increased costs. Research is under way that may lead to increased utilization of coal and possibly water as a hydrogen source. Some interesting research also is being carried out that may eventually lead to the fixation of nitrogen at significantly lower temperatures and pressures. This could lead to some real breakthroughs in the manufacture of nitrogen fertilizers over the next decade.

Over the short run the IFDC does not propose to undertake basic research in the above mentioned fields. The IFDC staff will, however, maintain close liaison with such work worldwide, and IFDC support will be available where additional inputs would accelerate results that could be used in IFDC work to lower fertilizer costs for LDCs by new production techniques. The IFDC will also stand ready to assist in pilot plant work and scale-up of any new technology that may be forthcoming.

The other major nutrients, phosphorus and potassium, as well as the secondary nutrients, calcium, magnesium, and sulfur, although not well distributed in some regions do occur in abundance in nature in various mineral forms. Only a few mineral forms and selected grades, however, are utilizable under present technology. Major research and development efforts will be carried out to develop technology that will permit a wider range of raw materials and permit additional indigenous sources to be utilized in the manufacture of fertilizers. Primary emphasis will be on phosphatic minerals and on sources of potassium and sulfur. Because potassium will soon become a limiting element when crop removal is stimulated by additions of nitrogen and phosphate, economically feasible sources of replenishment must be made available. Interest in sulfur will be primarily to obtain expanded and cheaper means of obtaining sulfuric acid which is used in the solubilization of phosphate rocks. In some instances sulfur will also be of interest as a plant nutrient. The major approaches will be:

1. Improved beneficiation technology. Physical and chemical means of separating desirable fractions of ores will be explored. A laboratory utilizing the latest equipment and staffed by geologists, chemists, and chemical engineers is envisaged. Technology will be developed that permits utilization of varying mineral forms as well as lower grade ores. Also, greater degree of extraction from presently

utilizable ores will be researched. Beneficiated ores will be evaluated both for direct application use and for further processing.

2. Improved processing technology. Various techniques of solubilizing phosphates and other nutrients will be researched. Acidulation studies will consider different acidulants, concentrations of acidulants, time of acidulation, partial acidulation, etc. Thermal methods will also be studied, with and without fluxing materials, to determine the degree to which availability of nut rients for plant growth can be improved. Primary emphasis will be on processes that permit the use of domestic deposits for local markets and not on techniques to encourage development of large scale deposits for competing on the world markets.

3. Improving physical properties and methods of handling fertilizers. Most modern fertilizers are extremely hygroscopic(they absorb moisture from the air) and will deteriorate rapidly when exposed to the atmosphere. This is particularly true in the humid tropics and is especially costly to the farmer who has inadequate on-farm storage. Improved and reasonably priced fertilizers which have physical qualities that can better withstand high temperatures and humidities and thus eliminate excessive deterioration and losses, or the need for costly packaging, will be a primary objective of this work. Local raw materials and limited geographical market areas will receive primary attention in this work. Through improvements in granulation, conditioning materials and methods, light coatings, etc., methodology for bulk handling in the tropical countries will be developed. Fertilizers that fit the needs of small and limited-resource farmers will be the goal. Based on existing knowledge the probabilities of success for such research are good.

4. Satisfying nutrient needs other than nitrogen, phosphorous and potassium (N, P, & K). Only the three major nutrients are recognized as important in temperate agriculture. Indications are that for tropical agriculture the so-called secondary nutrients, sulfur, magnesium and calcium, may at times be needed in large quantities. The most logical means of furnishing them may be by inclusion in the fertilizer mixtures. In the past sulfur was available in fertilizers such as ammonium sulfate or single superphosphate. But as the N, P and/or K content of fertilizers was increased, the sulfur was eliminated in products such as urea, ammonium nitrate, triple superphosphate and ammoniated phosphates. Technology that retains at least some sulfur in the fertilizer may be needed for optimum crop yields in the tropics.

The magnesium and calcium requirements of temperate zone crops are usually provided by liming materials that are used in large quantities to adjust the levels of acidity in the soil. Calcitic or dolomitic limestones, however, are often not readily available in the tropics;

thus the nutrient requirements for calcium and magnesium may best be included as a component of the fertilizer. Work should be started immediately to determine the true needs for these elements and how best they can be supplied. Micro-nutrient deficiencies in minerals are also widely reported as being more prevalent and important under tropical conditions. As yields increase these deficiencies will no doubt become even more pronounced. The IFDC will encourage research to better determine and delineate such micronutrient needs.

C. Agronomic Research

All of the foregoing lines of research have agronomic components. Beyond the laboratory and greenhouse research and initial screening of new products at IFDC, agronomic work must be carried out in the developing countries. Field studies of efficiencies in production resulting from the use of various fertilizers will need to take into consideration characteristics of the soils and climates of different regions. To be meaningful they must include evaluation of fertilizer response as a factor in the overall aspects of the soil and crop management systems possible in the pertinent regions. The interactions of fertilizer treatment with variety selection, tillage operations, planting dates, water management and cropping regimes will be essential for evaluation of fertilizer use.

Such research will be accomplished through cooperating institutions such as other international centers, ministries of agriculture, industry organizations, etc. The role of the agronomists located at the IFDC will be primarily that of overseeing the initial testing of new products, and as liaison with other organizations that will conduct field research, carry out the necessary testing and demonstration of new products, and provide feedback to the IFDC on the problems that need research and development attention.

D. Fertilizer Marketing Research

The objective is, through improved marketing, to provide fertilizers of the right kind and amount, on a timely basis, at the least cost to the farmer. Marketing costs, including transportation, storage, handling, packaging, advertising, credit, etc., often account for a major share of the cost of the fertilizer to the farmer. This is especially true in developing countries where low volume and a lack of marketing experience prevail. Saving on marketing costs can have a significant effect on the economics of using fertilizer. Studies to secure data regarding the most feasible transportation system are essential. The IFDC will perform the following functions.

1. Maintain and provide strategic information. Information on supply and demand, pricing, transportation, inventories, trade flows,

investment costs, etc. will be collected, collated and analyzed by computer techniques on a worldwide, regional and major country basis. Basic information from these data banks will also be available to interested parties for their use in planning. Care will be taken to avoid duplication and to draw as much as possible on data compiled by FAO, USDA, and other governmental organizations, trade associations and other sources.

2. Contribute methodology and assistance in determining the economic and sociological benefits of fertilizer usage. Many factors must be considered in the decision to use fertilizer and the kinds and amounts to use. Poor choices can be costly to the farmer as well as to the country. Economic and sociological analyses, early in a project or in some cases prior to the start of a project, can be most meaningful in setting goals and sites of the researchers. Often an understanding of the order of magnitude of fertilizer response that will be required to have appreciable impact on the adoption of new fertilizer by farmers can be an important guide to researchers. Governmental programs can significantly affect the economics of fertilizer use, as well as the knowledge and confidence that the farmer has in making his fertilizer use decisions.

3. Develop and provide guidance on organizational and operational aspects of good marketing systems. From experience gained in the study of successful and efficient marketing systems, information and guidance will be provided on the functions and interrelationships of various activities that go to make up successful and aggressive marketing systems. This will consider such things as organizational setups, incentive programs, goal setting, product knowledge, planning and scheduling of activities, training and information programs, etc. This should result in the development of various manuals that will be useful in training, teaching, individual study, etc.

4. Provide guidance on logistics and infrastructure. The location of the various components of a fertilizer industry in relation to existing uses and the potential for development of infrastructure is critical. Poorly located facilites as well as inadequate infrastructure to handle raw materials or finished product can cause poor production records as well as high priced products. Experience and know-how, along with well designed computer programs, will be provided to help eliminate costly and long lasting errors.

Technical Assistance

A major role of the IFDC will be to provide assistance to existing fertilizer industries, to governments, to wholesale and retail distributors, to control officials, etc., to improve efficiency, reduce costs, and assure the consumer of fertilizer quality and quantity. For the

most part techinical assistance will be provided in response to requests. However, suggestions will be made by the IFDC on ways to improve basic resource utilization, fertilizer production, infrastructure development or marketing that may lead to the need for assistance from the IFDC. The costs of technical assistance will be passed on to the beneficiary of this assistance wherever possible.

Training must be one of the major activities of the IFDC. Training by the IFDC will be defined to include everything from formal courses to on-the-job training, to observation, to work experience, to seminars, and to providing information to improve the skills and techniques of the individual and of the operation in total. Training will be offered in all phases of fertilizer production, marketing and use. Staffing of the IFDC will as far as possible provide specifically needed experience and know-how, as well as teaching ability and language competence.

International Linkages

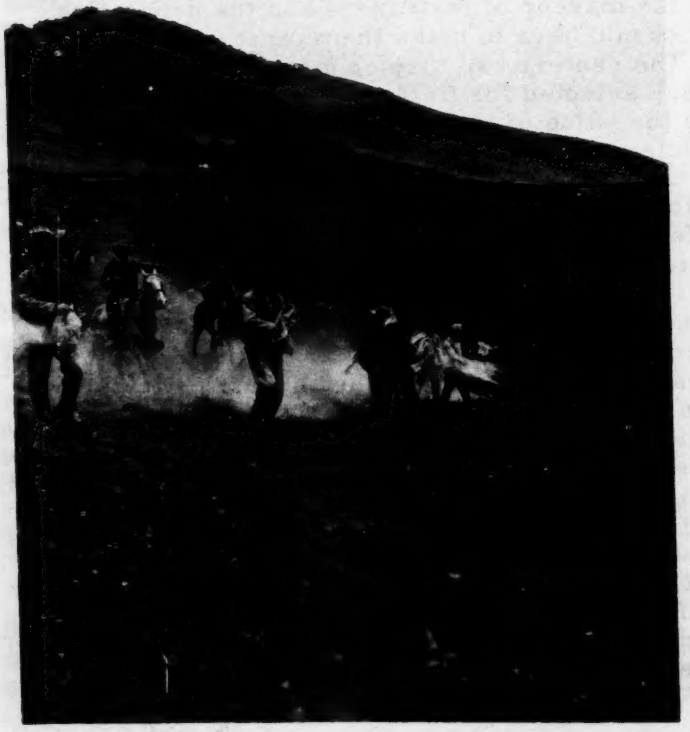
The linkage with other international and national agricultural research centers will work in both directions. Problems which specialists in other centers recognize as relating to fertilizer will be worked on cooperatively by the centers and IFDC. The definition of basic crop needs by scientists at the other international centers will give the IFDC staff guidance on the makeup of fertilizers and the properties which these fertilizers should have to make them most useful in particular situations. The centers can also cooperate in testing and evaluating new fertilizers selected for field test by the IFDC, and assist in demonstrating the value of those which have superior characteristics and efficiency. In particular, soils research projects in tropical areas can have a direct impact on the investigations undertaken or given priority by the IFDC. This will be especially true of studies of soil-fertilizer interactions and their relation to the availability of plant nutrients.

It is anticipated that the IFDC will continue and expand ties directly to the industries, governments and universities of the developing countries. Many of these ties will be established during training sessions or technical assistance efforts. Some will be inherited from the TVA projects; testing of sulfur coated urea in the All-India Coordinated Rice Program is an example which has been especially successful. Close relationships with the fertilizer industry worldwide have been established and will be expanded with the creation of the IFDC. Such organizations as International Superphosphate Manufacturers Association, Ltd., Fertilizer Industry Advisory Committee, Associacao Nacional para Difusao de Adubos of Brazil, Fertilizer Association of India, Fertilizer Industry of the Philippines, The Fertilizer Institute of the United States, and others will play prominent roles in assisting the IFDC in carrying out its program.

Patent Policies

As a research and development organization, the IFDC will generate patentable discoveries in the form of new ideas, new fertilizer materials, new processes, new equipment, etc. The objective of the IFDC will be not only to encourage such discoveries but also to assure and encourage their widespread availability and use. All such discoveries will be registered and/or patented with the proper authorities under U. S. patent regulations. Such patents will be considered public in nature and will be available to any and all interested parties on a nonexclusive basis, within and outside of the United States.

[Extracted from the formal Proposal for Program and Operations by the IFDC, presented to the U. S. Agency for International Development and the Canadian International Development Research Center, May 1975. Supplemented from an IFDC brochure.]



Local method of fertilizing pastures in Ecuador.

(Photo: FAO)

VILLAGE TECHNOLOGY

SIMPLE MACHINE INTRODUCED IN THE VILLAGE OF SAN GERARDO, BOLIVA, WHICH REDUCES THE TIME NEEDED TO MAKE A BALL OF TWINE FROM ONE DAY TO ONE HOUR.
(PHOTO: UNITED NATIONS)

The Bamboo Tube Well

Arthur J. Dommen

[The invention of a type of irrigation tube well made of bamboo, and the advantages of this device in the conditions of Bihar, India, where relatively shallow water tables and suitable soils are found, are described.]

In the course of a field trip through the state of Bihar, India, in July 1973, I witnessed an example of locally invented technology: a bamboo tube well, or bas boring as it is called locally. It is simply a tube well made from split bamboo lengths, iron rings, and coir string. Its construction is as simple and economical as is its sinking into the ground, and when a rubber hose attached to a 5-horsepower diesel pump is dropped into its open top, it yields water in quantity.

Saharsa District of Bihar, where the bamboo tube well was invented, and adjoining Purnea District lie within the command area of the Kosi Project, a combined flood protection and irrigation scheme intended to distribute the waters of the Kosi River over a vast area of potentially extremely fertile land. Since the canals first carried water in 1964-65, however, the Kosi Project has been plagued by numerous troubles. Most serious at the moment is the problem of sedimentation, for the Kosi ferries a very fine-grained grayish silt. This is deposited in large quantities on the bottoms of the main, branch and distributory canals and, worse yet, in the paddy fields receiving canal water, where it exerts a deleterious effect on plant growth. The Bihar government has been compelled to close the canals

Mr. Dommen was a graduate student in agricultural economics at the University of Maryland.

entirely for a 3-month period every year in order to clean them out and so bring the flow levels back into line with what had originally been planned. Aside from the heavy cost involved, this annual closure plays havoc with cropping schedules. Another problem has proved to be waterlogging of lands adjoining many of the canals. These problems and others have greatly reduced the extent of utilization of irrigation water. Even in villages close by the canal, farmers have been deterred from committing themselves to drawing water because of the sheer unpredictability of whether they will receive water to irrigate their fields at the proper moment.

It was the lure of water for irrigation, when it was not forthcoming from the Kosi canals, that led the inventor of the bamboo tube well to make his experiment. Mr. Ram Prasad Choudhary, who lives in Lalpur village, Saharsa District, where he owns a middle-sized farm, described how in December 1968 he drew a loan to sink a tube well to irrigate his 6 or 7 acres of Mexican wheat. At first Choudhary made an unsuccessful trip to Purnea District in quest of iron pipe. Choudhary returned home and began repairing his hand pump, which needed a new water filter. He had purchased some coir string in the bazaar, and he was struck by the fact that coir string possessed two especially valuable properties: (1) it does not pass sand, and (2) it does not rot in water. Such material could possibly be used to line a tube well, he though. The giant bamboos that grow in Saharsa would probably serve for support, and he found one that had a straight stem and was at least 3 years old.

The people of Saharsa are used to working with bamboo. They split the stems with skill for use in building the walls and roofs of their houses and in making furniture. Chouldhary fashioned two pipes, each about 25 feet long and 4 inches in diameter. Using split bamboo stems nailed to iron rings as a frame, he wrapped one pipe which was to serve as the lower section with two layers of coir string, and the other, for a top, with one layer of coir string and one layer of polyethylene sheeting, also purchased in the bazaar. Choudhary's work attracted a good deal of attention among his neighbors in Lalpur, and someone went off to inform Mr. K.K. Tripathi, the project executive officer (PEO) in the Singheshwar Block office, about 3 miles away. The PEO arrived on the spot; he thought it looked like a good idea, offered encouragement, and went to negotiate with a local tube well driller for boring the necessary hole. Nine laborers were recruited.

The bore was 8 inches in diameter. The main problem, Choudhary said, was to lower the bamboo pipe, which had been joined into a single length 50 feet long, into the hole. On the first attempt the pipe bent and broke as it was being slowly raised into position. On the following day in recognition of the need for a more systematic approach, a bamboo scaffold was constructed to hold the pipe in place above the bore with the help of ropes. This second attempt was successful. With the pipe

in place, a 5-horsepower diesel pump was brought to the scene.

At first they ran the pump at slow speed lest the suction collapse the rather flimsy walls of the pipe underground. Then Choudhary said to himself, "If this thing is going to collapse, let it collapse," and he ordered the pump run at high speed. He prayed. After about 15 or 20 minutes of pumping, a fountain of water gushed forth. There was pandemonium among the spectators, Choudhary recalled. People started running to the village and to neighboring villages. By evening the news had reached the block and district headquarters. Next morning the PEO came and informed his agricultural development officers of the success.

Choudhary's bamboo tube well was officially inaugurated in the presence of a dozen government officials at a ceremony on the site on January 28, 1969. The publicity resulted in small workshops being set up to construct the bamboo and coir tube wells. Today one sees them all over Saharsa and Purnea. In both districts the predominantly sandy soils make the bamboo tube well an ideal device for gaining access to the wealth of water underlying the ground surface, and more than 100,000 acres have been brought under bamboo tube well irrigation. In the 6 months ending March 1973, more than 33,000 bamboo tube wells were sunk in 10 districts of Bihar.

The great advantages of the bamboo tube well stem from the following characteristics: (1) it can be constructed entirely of indigenous or easily available materials (unlike the iron pipe tube well); (2) it is so light it can be carried by a single man; (3) it is cheap; (4) since it is cheap, it is expendable in case the tube well dries up; (5) also since it is cheap, one farmer can afford more than one tube well, an important consideration in an area like Bihar, where consolidation of landholdings has not yet taken place and ownership of many small, scattered plots is the general rule; (6) when homemade, the bamboo tube well obviates the necessity of obtaining a loan from the moneylender or government agencies.

The bamboo tube wells that are being constructed in village workshops today differ hardly at all from Choudhary's original prototype. For example, a tube well comprising three 25-foot sections requires the following elements: 60 1-inch-wide iron strips that can be shaped into rings (cost, 2 rupees each); split bamboo costing a maximum of 10 rupees; an expert bamboo artisan, who is paid 3 rupees per day; coir string worth 75 rupees; and nails worth a few rupees. The total cost would be 215-225 rupees (about $29-30).

Sinking the bamboo tube wells is done mostly by specialist engineers. The cost of boring is estimated as 1.50 rupees per foot. The total cost of sinking a bamboo tube well to a depth of 60 feet, including con-

struction materials, boring, and labor, will come to more than 200 rupees but less than 300 rupees ($30-40). This is approximately 10 percent of the cost of sinking an iron tube well to the same depth. The useful life of the bamboo tube well is placed at between 3 and 5 years, which is certainly less than that of an iron pipe tube well. Choudhary's original 1968 bamboo tube well was still producing water when I visited Lalpur in 1973.

The following depths of boring are recommended in an official booklet of instructions for varying soil conditions. With the water table at a depth of 10 feet, the tube well should be sunk to a minimum of 35 feet through coarse sand, and with nothing but fine sand in the bore, a minimum of 50 feet. With the water table at 15 feet, minimum depths vary from 45 to 60 feet with soil type. With the water table deeper than 20 feet, a 20-foot iron pipe should be used atop a 40-foot length of bamboo tube well. The figures quoted give some indication of the shallowness of the water table in these districts, which probably represents a limitation on the areas where it can be used. In addition, the bamboo tube well is reportedly not adapted to heavy clay soils.

The first bamboo tube wells to be sold were built entirely with private initiative and private expense by mechanics whose workshops were in the towns. Later, the business was taken up by village artisans, who found that they could profitably sell the bamboo tube well for about 50 rupees less than the town mechanics, and the latter were driven out of business. Today, any enterprising farmer can build his own bamboo tube well.

The real bottleneck to further dissemination of the bamboo tube well is now the cost of pumping sets. Officials in Bihar are of the unanimous opinion that what is required to overcome this bottleneck is a pumping set selling for under 1,000 rupees, compared with the cheapest one available on the market at present, which costs 3,125 rupees. Equipped with the standard 5-horsepower diesel engine, a bamboo tube well has a delivery capacity of 7,000-8,000 gallons of water per hour. The pumps have been made more efficient by mouning them on the flatbeds of bullock carts and wheeling them from tube well to tube well in rotation. In progressive farming areas like Begampur, the block sanctions loans for groups of five farmers to finance one pumping set to share among themselves; under this scheme, each farmer stands guarantor for the other four.

The bamboo tube well, because it is cheap enough to be installed by small landowners who formerly lacked irrigation facilities, has increased the intensity of land use among this class of farmers. I found no instance of very big landholders installing bamboo tube wells. The introduction of the bamboo tube well has thus had the effect of selectively increasing land productivity in such a manner as to narrow

somewhat the wide income gap that exists in Bihar between small and large landowners. As for labor, there can be no doubt that the bamboo tube well has proved to be a labor-intensive technological innovation. It enables its owner to accelerate his cropping schedule by taking advantage of the high-yielding seed varieties that require for their growth assured and timely supplies of irrigation water and that take a shorter period to mature. This acceleration increases the number of man-hours worked and puts labor to work. The increased utilization of this simple device also frees the farmers from the vagaries of the monsoon since it can be used in times of drought.

[Extracted from "The Bamboo Tube Well: A Note on an Example of Indigenous Technology," Economic Development and Cultural Change, Vol. 23, No. 3, April 1975, pp. 483-489. Copyright©, The University of Chicago Press, Chicago, Illinois.]

Rural Technology in China

H. Dickinson and T. L. Winnington

[Rural technology used in mainland China is of interest for countries where conditions are similar. Some examples from Chinese manuals of instruction for farmers are shown.]

China with its long history of invention and innovation, provides a rich and varied source of simple techniques and artifacts for agriculture and the processing of agricultural products. In recent years great emphasis has been placed on self-help and self-reliance; with this in mind, leaflets and books illustrating simple tools and machines have been distributed widely throughout rural China. Much of this material deals with the construction of devices and consists of basic arrangement diagrams with explanatory design notes. These are rarely complete in detail and leave much to the skill and experience of the constructor.

For a particular process self-help leaflets describing several alternative designs are likely to be available; final choice will depend on available skills, conditions of use, and the properties of local constructional materials. Though presenting some initial difficulties this approach fosters experience in innovation and adaption. Machines built in this way are a common feature of China today and may be seen throughout the country in many modified forms.

The earlier self-help leaflets were themselves cheaply produced single sheets printed, rather crudely, on coarse paper. As the rural areas became more

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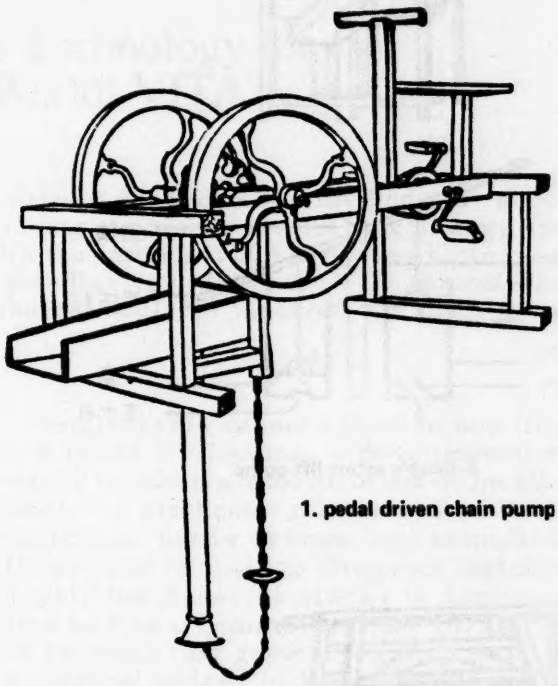
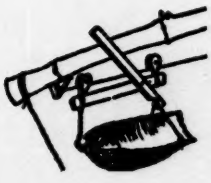
prosperous, and levels of literacy and skill increased, they were supplemented by well produced manuals dealing with many kinds of activity from the forging of simple farm tools to the maintenance of the electric motors which have been introduced with the spread of rural electrification.

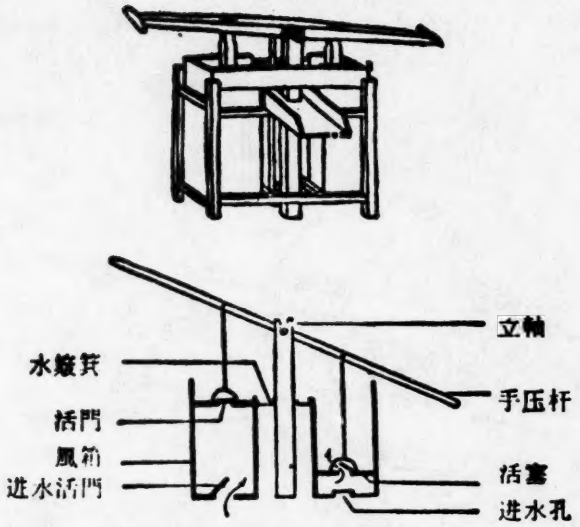


1. pedal driven chain pump

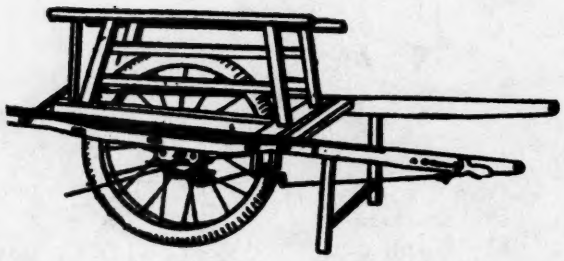
The illustrations, taken from self-help leaflets, show some typical mechanisms used in rural China. Figure 1. Pedal driven continuous chain pump derived from the 2,000 years old dragon's spine (square-pallet chain) pump. Figure 2. Simple lever and transfer basket for earth moving, such as the removal of silt from irrigation channels. Figure 3. Double-acting lift pump with square-section cylinders which can be constructed from wood by a carpenter. Figure 4. Single wheel handcart, perhaps the most universally used cart in China. It may be seen in both town and rural areas.

2. lever and transfer basket





3. double acting lift pump



4. single wheel cart

[Extracted from "Rural Technology in China," Appropriate Technology, London, England: Intermediate Technology Publications Ltd., Vol. 1, No. 1, 1974, p. 13.]

Appropriate Technology for The Third World: VITA

VITA Sources

[The following article describes the methods for supplying technical assistance in solving problems of rural technology used by a U. S. organization with the initials VITA. A case history, involving a water mill for grinding corn in Malawi, is summarized to indicate the kinds of technical decision involved and the advice which was provided.]

Bangladeshis cannot afford to buy imported soap, and David J. Hopkins, a development worker in Dacca, wants to make a substitute out of locally available materials. A Methodist missionary in Bolivia, Robert L. Caulfield, needs to know how ammonium phosphate fertilizer can be used to fireproof thatched roofing. J. S. Joshi, the fisheries officer in Jamnagar, India, would like to find a commercial use for the copious supplies of seaweed that grow along his coast. Donald Brownlie, a medical officer in Livingstonia, Malawi wants detailed information on grinding corn by means of a water-powered mill (see below).

The common feature of these various needs for help is that all were made known earlier this year to an unusual but little known organization called VITA, or Volunteers in Technical Assistance. With headquarters in a former convent in the suburbs of Washington, D. C., VITA relies on a nationwide network of some 6000 scientists and engineers who have agreed to give free advice to people with technical problems.

Most of the 1500 requests VITA receives each year

This article was composed by the Associate Editor from materials supplied by VITA.

come from the developing countries, with about a third each from Africa, South America, and Asia. Many can be answered by provision of material from VITA's library. Problems needing individual attention are forwarded to one or more volunteers with relevant expertise. They will suggest a technical solution, and provide continuing advice to the requester until his problem is solved. In the course of rendering advice VITA scientists and engineers have designed such implements as windmills, Savonius rotors, methane gas generators, Archimedes' screws, low-cost tractors, bicycle powered pumps, and solar cookers.

The emphasis in VITA's advice to Third World countries is on "appropriate technology," the use of skills and materials that are locally available, or, if equipment has to be imported, on designs that can be repaired by the village craftsman. Much of the volunteer advisers' experience has been incorporated into a Village Technology Handbook, [Obtainable from VITA for $9.00 — see address below]. This manual tells you much of what you need to know about basic life-support systems from the digging of wells to the salting of fish and the cutting of bamboo pens.

VITA has a headquarters staff of 20 and an annual budget of about $500,000 to which the Agency for International Development is the largest single contributor; other funds are supplied by private foundations. Local VITA branches have been established in Nigeria, Brazil, the Philippines, and Central America. The organization reckons to have answered more than 25,000 requests from 100 countries.

In answering these requests, VITA volunteers are asked to keep in mind the approach described by Michael Greene, technical director for VITA. In his words: My definition of appropriate technology is modern scientific and engineering ideas applied to the problems of the developing countries and adapted to their economic, cultural, and social needs. This means, basically:

1. Increase production. The new way should help people to produce more than the old way.
2. Make use of labor. These countries have many people needing work. VITA requestors generally don't have money to buy and maintain imported labor-saving machinery.
3. Use local materials. Solutions should use material the requestor has available, e.g. bamboo, wood, old oil drums, bicycles, simple tools, and not material he has to import, like steel, gasoline, or expensive machinery.
4. Use local resources. People whose annual income is less than $50 cannot afford to buy and maintain a pump or machine costing $100. We try to design one they can build for $5, and once built can be easily and cheaply maintained.

5. Conform to local traditions or customs. This involves our asking such questions as "will women or men be using the apparatus?" and "how large a community will be able to pool resources and cooperate to build it?" Here we must rely on guidance from the requestor.

Requests come in various forms; some can be answered quickly and easily, and others involve many volunteers over a longer period of time. One such request came to VITA from Livingstonia, Malawi over a year ago. This request triggered a chain of communications from many different sources, with VITA serving as the center for the interchange of information.

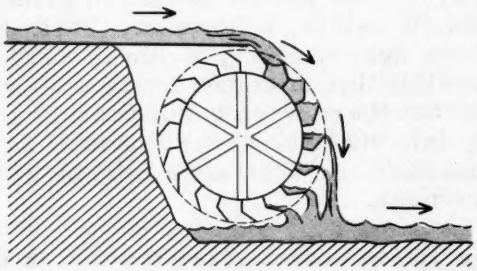
Request for Design of a Water Wheel for Grinding Corn in Malawi

A medical officer, Mr. Donald Brownlie, was working in an isolated rural hospital in an area called Mlowe on the banks of the River Rukuru. A viral disease had destroyed the local crop of cassava, and the government of Malawi was encouraging the planting of corn (maize) to replace the cassava. The people needed to grind their corn, but the nearest mill was 30 walking miles away. Mr. Brownlie, noting the water power of the nearby river, wrote to VITA on June 18, 1974 asking about the possibilities of constructing a water-powered grinding mill. He wrote that there wasn't much money for the project (VITA supplies only information, never financial assistance), but he hoped it would be possible to construct a mill before the winter rains arrived in mid-December.

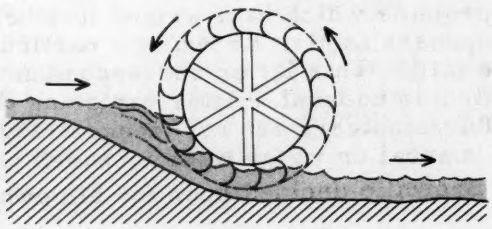
The following description summarizes the way in which VITA volunteers helped design the Mlowe waterpowered grinding mill during the next year. This involved correspondence to and from Malawi as well as VITA volunteers in 5 states; with the VITA head office coordinator, Mr. George Codrea; with a missionary engineer in Malwi, Mr. N. Newman; an English technical assistance group called OXFAM; and some commercial milling firms. When examined in chronological sequence, these letters tell the story of how to suit appropriate technology to a specific problem. The file, kept at the VITA home office, illustrates all the various kinds of assistance VITA gives: 1) VITA publications which have been written for general information requestors; 2) copies of articles which have been published in other journals; 3) letters from VITA volunteers with advice on specific problems and solutions used in projects which have arisen in other parts of the world; and 4) specific responses to Mr. Brownlie's particular questions on building his Mlowe mill. This latter correspondence is what makes the VITA information so unusual. After exploring these water wheel questions, the VITA volunteers are now concentrating their efforts to develop a basic manual on water wheels, based partly on some of the solutions Mr. Brownlie decided upon for his own project.

The story of the Mlowe Mill is divided here into three topics on which technical decisions were needed. Separate solutions had to be found to these problems: 1) the water wheel, and its gearing mechanism; 2) the grinding process; and 3) the housing for the machinery. Many options were explored for each set of problems.

The Wheel. In the first reply from VITA to the original request, the VITA library sent a pamphlet called "Cloudburst" which explained the two major kinds of water wheel and their relative advantages. The overshot wheel is the most common, so called because the water enters at the top of the wheel and "shoots" over it. Along the circumference of this wheel are a series of "buckets" to catch water at the top position of the wheel, and most of the work is done by the weight of the water as it descends in the buckets. It is important to design a wheel that allows for the proper filling of buckets which will contain the water until the lowest point in the circumference of the wheel where they empty. The wheel should not dip into the water in the tail race because of the resistance this water would present to the buckets as they passed. The efficiency of this wheel is 70 to 90 percent, which means it uses that percentage of the water which flows from the sluice.

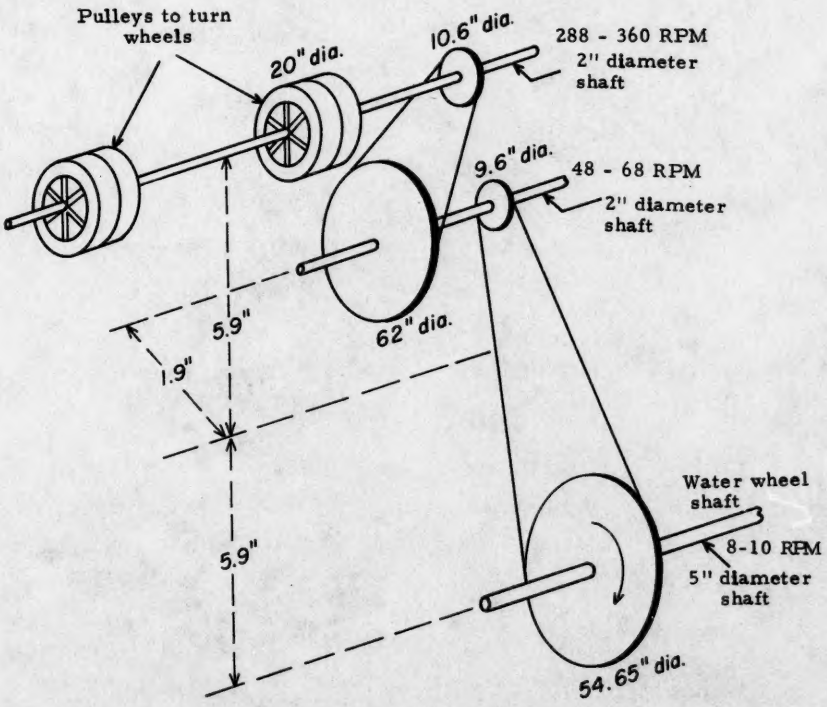


The breast wheel is used where the waterfall is short (less than 10 feet) but the water flow is abundant. The water is channeled into the wheel at a 10° to 25° angle from the entrance of the sluice. The action of the wheel comes partly from the flow of water underneath it but also from the weight of the water in the buckets. There need to be air holes in the buckets, and the inner edges of these buckets should be rounded in order to reduce the losses from friction, and in other ways the requirements for bucket design are quite different for the two wheels. The efficiency of the breast wheel is rarely more than 70% and the usual range is 50% to 70%.

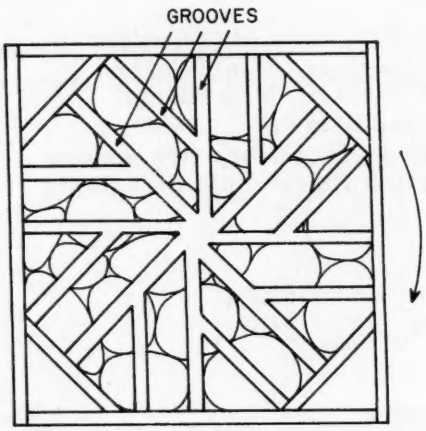


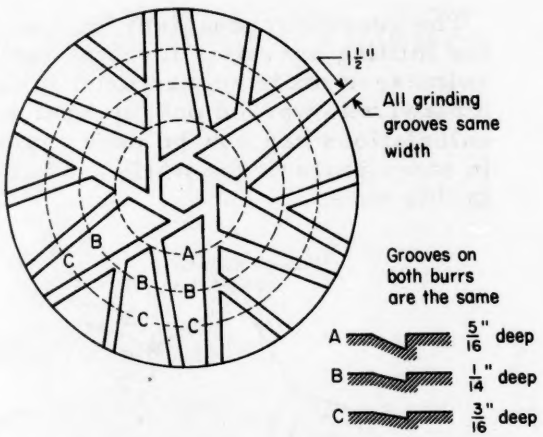
At first, Mr. Brownlie decided that a breast wheel would suit the Mlowe terrain which was fairly level. With Mr. Newman, he had figured out how to build a mill pond and a retaining wall to redirect the water. They calculated the depth of the fall which they would create to be about 9 feet. But this solution was immediately challenged from two sources: an OXFAM assistant suggesting an overshot wheel; and a VITA volunteer claiming that an overshot wheel would be easier and safer to construct and set up, that an overshot wheel was more reliable, and that there were not venting problems with it. So Mr. Brownlie agreed and decided on a small overshot wheel apparently because of the efficiency of its use of the water. Brownlie finally created a drop of 14 feet for the water by clearing more boulders. This meant that a 11' 9" wheel could be accommodated. Further correspondence and decisions (not described here) were concerned with the precise shape, angles, size and numbers of the buckets on the wheel.

The gearing mechanism for transferring the power of the wheel to the milling operation involved further calculations. Many VITA volunteers made suggestions; in the end it was Mr. Newman in Malawi who worked out the final solution (see diagram). His calculations can now be used again by VITA to help other requestors in other parts of the world. Thus information flowed both directions in this case.



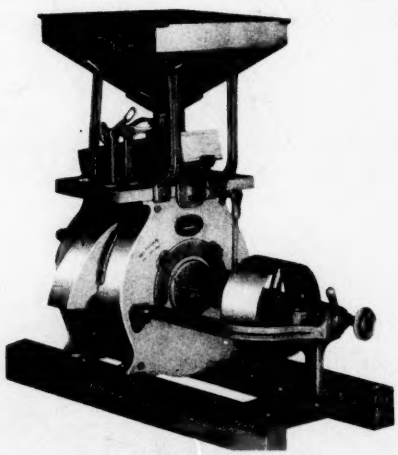
The grinding process. Brownlie originally wanted to use a traditional method of grinding, by shaping mill stones from the granite found in the area and placing them in a locally built wood frame. He realized, however, that it was very difficult to carve the required grooves in the rock, and that they wore down very quickly. After various requests he contacted a millwright in New York who could carve and set the stones for him. But most of the volunteers from VITA and from OXFAM thought commercial milling units would be more practical for his situation. The commercial mills include small grooved mill stones inside a manufactured metal frame. Brownlie didn't have much faith at first in the commercial milling units, and thought he might need a back-up with a traditional set of stones which he could use if the commercial mill did not work out. In his final letter he was still talking about getting air fare for that millwright from New York.





ABOVE: Locally made grinding wheel: left stones in frame; right detail for grooves in stones.

BELOW: A type of 20" commercial grinder machine used in the Mlowe Mill



The people of Mlowe had a definite preference for well-ground meal. As Brownlie stated: "If the flour isn't fine enough, folks would rather walk 30 miles to the next mill than use flour which is not to their liking." So the question of quality became decisive, since the commercial mills would be more reliable in their product. VITA had sent information on a commercial mill from North Carolina which Brownlie seemed to like. OXFAM recommended an English mill which they knew better. The latter turned out to be very expensive; and upon enquiry from OXFAM, Brownlie discovered that other African users had had to run their maize through twice — which meant that the output of 400 pounds per hour would be cut in half. In the last letter to VITA on May 9, 1975 Mr. Brownlie reported that he was anxiously awaiting a 26 inch mill from North Carolina which he hoped would live up to his need for processing 500 pounds per hour with the proper quality.

The housing. Two other VITA volunteers helped with the question of housing the gearing mechanism and the mill. The housing problems consisted of two parts: ventilation and grain storage. The ventilation of the mill is important so the large quantities of dust generated in milling would not accumulate. Grain dust on the walls and ceiling soon leads to pest infestation, gets into the grease of the machinery, and makes breathing difficult. A VITA volunteer sent various ideas for remedies, including plans on how to build a cyclone dust remover machine which would focus dust into a bag rather than blow the dust outside the building. Another idea was to exhaust the rooms of the mill by fans blowing the dust out through the roof. Other ideas involved openings in the side of the building, and the use of a separated area under the roof for dust collection.

The housing plans also had to consider whether there needed to be large storage areas for use either before the maize was milled or after it was milled. Information as to how to keep the moisture from the maize, and to protect the grain from rats, mice, and insects was all in the literature sent by VITA. VITA even contacted an agricultural resaerch station in Boumbwe, Malawi which sold various kinds of storage containers. Unfortunately the file does not indicate exactly which of the many suggested solutions Mr. Brownlie decided to adopt. In his last letter he stated only that the mill building was going up.

This story of the construction of the water-wheel grinding mill of Malawi illustrates some of the ways in which VITA can help solve specific technological problems presented by requestors. Alternative sources of technological assistance for rural problems are listed below.

[Adapted from the file on this case collected by VITA: Volunteers in Technical Assistance, Mt. Rainier, Maryland, 1975.]

Appropriate Technology Institutions

Volunteers in Technical Assistance (VITA)
3706 Rhode Island Avenue
Mount Rainier, Maryland 20822, USA

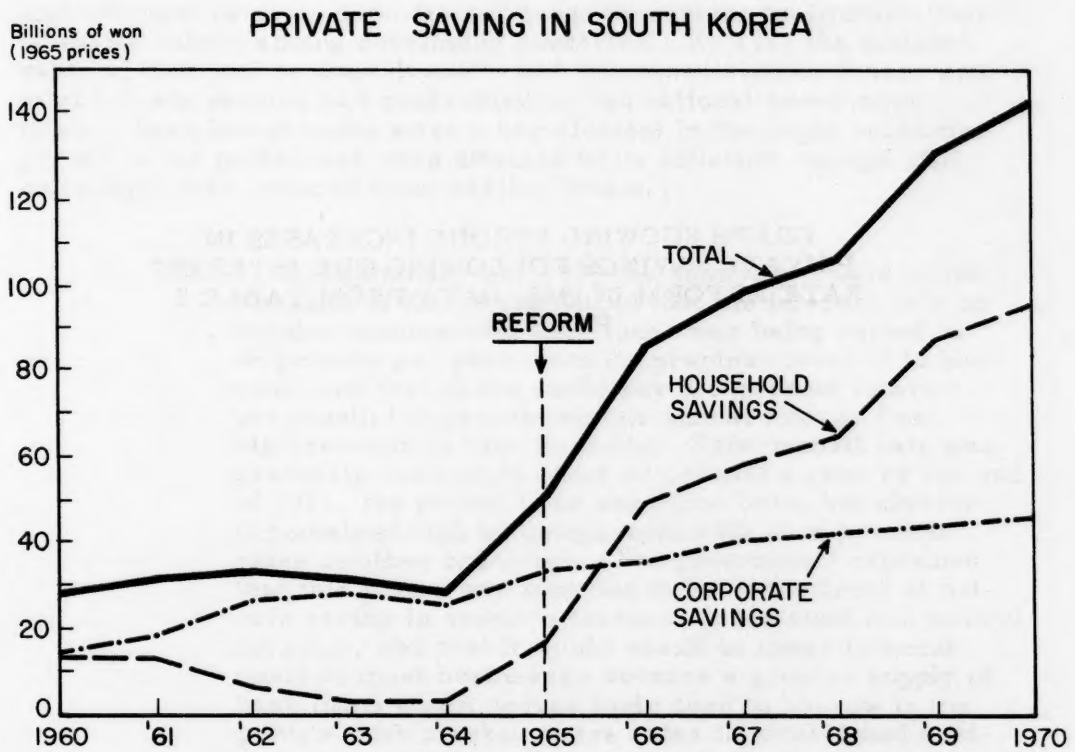
Intermediate Technology Development Group (ITDG)
Parnell House
25 Wilton Road
London, SW1V 1JS
England

OXFAM-UK
272 Banbury Road
Oxford, England

Brace Research Institute
MacDonald College of McGill University
Ste. Anne de Bellevue 800
Quebec, Canada
(Solar Energy & Windpower Research)

Canadian University Services Overseas (CUSO)
151 Slater Street
Ottawa, Ontario
Canada K1P 5H5

INTEREST RATE REFORM



GRAPH SHOWING STRONG INCREASES IN PRIVATE SAVINGS FOLLOWING THE INTEREST RATE REFORM IN 1965; DATA FROM TABLE 2, PAGE 70

Korea's Interest Rate Reform and Domestic Savings

Gilbert T. Brown

[In 1965 the government of South Korea began an experiment with high interest rates on deposits and loans by banking institutions that is nearly unique among developing countries. By 1971 the deflated value of time and savings deposits had increased sixteen times, and total private savings had quadrupled as had national investment totals. Such investments were a key element in the rapid economic growth of the period and were attained while inflation, though still quite high, was reduced from earlier levels.]

On September 30, 1965 the Monetary Board of the Republic of Korea announced that the interest rate on regular commercial bank loans was being raised to 26 percent per year from its previous level of 16 percent, and that banks would pay 2.5 percent interest per month (30 percent simple annual interest) on eighteen-month time deposits. This deposit rate was gradually reduced to about 20 percent a year by the end of 1971, the period to be examined here; but clearly it remained high by comparison with such interest rates in other countries. The government explained that this policy was intended to boost the level of private saving in order to increase investment and control inflation, and that it would result in lower interest costs to most businesses because a greater supply of bank loans would reduce their need to borrow in the private curb market where rates to established businesses ranged from 3.5 percent to 5 percent per month (42-60 percent a year). These various interest rates compare with annual rates of inflation, as measured by the GNP deflator, of about 30 percent in 1963 and 1964, falling to 8 percent in 1965; in 1966 through 1971

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prices rose 10 to 14 percent per year. Real (minus inflation) average annual interest rates on long-term bank deposits ranged from minus 17 percent in 1964 to plus 19 percent in 1967 (see Table 1), and on commercial bank loans from minus 16 percent in 1964 to plus 15 percent in 1967.

The September 1965 interest rate changes caused an outcry in Korean business circles and predictions that the higher level of bank interest rates would lead to bankruptcies, reduced growth, inflation, and other dire results. In fact, South Korea experienced more rapid growth after the interest rate reform than before, and predictions of more inflation and bankruptcy have not been borne out. The faith of government policy-makers that higher interest rates would add significantly to the availability of bank credit and to domestic savings seems to have been fully vindicated.

Table 1. Annual Average Interest Rates, Time and Savings Deposits, Bank Loans, and Money Supply
(percentages)

	Nominal interest rate on long-term deposits	Rate of inflation (annual change)	Real interest rate	Time & savings deposits, 1965 prices* (percent change)	Time & savings deposits as percent of money supply	Loans from banking funds 1965 prices* (percent change)
1957	12.0	19.2	−7.2	−5.8	10.3	—
1958	12.0	−0.5	12.5	36.6	11.0	25.3
1959	11.2	2.1	9.1	50.1	12.3	2.6
1960	10.0	9.1	0.9	11.9	13.7	11.8
1961	12.1	15.5	−3.4	5.9	14.0	2.6
1962	15.0	13.4	1.6	168.6	31.3	66.3
1963	15.0	28.2	−13.2	14.2	43.8	−2.5
1964	15.0	32.0	−17.0	−16.3	42.6	−17.8
1965	18.8	7.6	11.2	25.9	46.6	13.1
1966	30.0	12.9	17.1	111.0	84.9	34.2
1967	30.0	10.5	19.5	80.6	122.3	45.2
1968	27.6	12.0	15.6	99.6	206.3	60.9
1969	23.8	12.1	11.7	41.6	253.2	63.7
1970	22.8	14.2	8.1	14.2	223.2	26.3
1971	21.6	11.0	10.6	16.9	235.8	20.2

SOURCE: Bank of Korea

* Deflated by GNP price index, 1965 = 100.

Growth of Time and Savings Deposits

The term "time and savings deposits" in this study includes deposits at all commercial and savings banks plus such deposits at the

Korean Development Bank and money trust deposits. In addition, the National Agricultural Cooperatives Federation branches in numerous villages accept time and savings deposits, but their deposits are only a small part of the total value.

The effect of the interest rate change on time and savings deposits was immediate and dramatic. As deflated by the wholesale price index, the value of time and savings deposits rose by 50 percent during the final three months of 1965. For the next three years through 1968 these deposits increased at a compound annual growth rate of approximately 100 percent (Table 1). Though this growth rate slowed markedly thereafter, the real value of time and savings deposits at the end of 1971 was nearly sixteen times their September 1965 level. Such deposits rose from 3 percent of 1965 GNP in September 1965 to 20 percent at the end of 1968, and to 27 percent at the end of 1971.

Table 1 shows the average annual values or rates of change from 1957 through 1971 for interest rates, time and savings deposits, and bank loans. Time and savings deposits rose from less than half the money supply at the time of the interest rate reform to more than double the money supply (236 percent) at the end of 1971. The number of time and savings deposit accounts rose from 338,000 at the time of the interest rate reform to 2,968,000 by the end of 1968 and 5,957,000 at the end of the period. The real value of the average size of such deposits, after adjustment for inflation, rose by about 25 percent. Small savers seem to have concentrated more on six-month than on longer maturity deposits. Six-month deposits accounted for 60 percent of the total number of accounts at the end of 1968, but only 16 percent of the value of such deposits; the average eighteen-month deposit was ten times larger than the average six-month deposit.

The evidence already cited is ample to show that the 1965 interest rate reform had a profound effect on the public's desire to hold time and savings deposits. To examine their longer-term relationship, various measures of time and savings deposits and changes in these deposits from 1957 to 1971 were regressed on real interest rates, income, and other variables. The results suggest that income and interest rates were the important determinants of the growth of time and savings deposits. The high degree of correlation between real interest rates and income, however, makes it impossible to separate statistically their respective effects on savings deposits and on total saving.

The sharp rise in real interest rates in 1965 was as much a product of the dramatic slowdown in inflation as of the interest rate reform. In terms of annual averages (Table 1), the slowdown in the rise of prices to 7.6 percent in 1965, compared with 32 percent in 1964, was sufficient

to have raised the real rate of interest on one-year time deposits from a minus 17 percent per year to a plus 7 percent without any change in the nominal interest rate. While it is not possible to know by how much the change in actual rates of inflation changed public expectations as to the rate of future inflation, that it lowered these expectations is indicated by the 30 percent increase in time and savings deposits during the first nine months of 1965. The doubling of the nominal interest rates on long-term deposits from 15 percent to 30 percent at the end of September, however, served to increase confidence that the government intended to continue to control inflation as well as dramatically increasing the real rate of interest on such deposits. Consequently, banks were deluged with additional deposits and depositors in the last quarter of 1965.

The constant-price value of loans from banking funds (i. e. excluding bank loans made from government budget funds) increased by 45 to 64 percent annually in 1967 through 1969 (Table 1), which was an impressive rate of increase but substantially less than the growth in time and savings deposits. Thus it would have been possible to have increased bank loans even faster without any increase in money supply if there had not been large money supply increases from an inflow of foreign credits substantially in excess of Korea's current account balance-of-payments deficit. (This inflow of foreign credits was also due in part to the interest rate reform which increased the attractiveness of foreign borrowing as compared with domestic.)

There are several questions about the effect of interest rates on time and savings deposits which cannot be fully answered. One is the nature of expectations concerning the rate of inflation. Presumably it is the nominal interest rate adjusted for the expected rate of inflation, rather than the current rate of inflation, that determines investors' decisions about asset holdings and saving and investment. By referring to "real interest rates" we have in effect assumed that the current rate is also the expected rate of inflation for the relevant future period. This is probably as good as any other quantifiable assumption, although there are certainly times when it has not been true.

Other such questions are the extent to which the flow of time and savings deposits into the banking system following the interest rate reform represented merely the transfer of existing assets out of the informal private money market to financial institutions, or the liquification of other assets, rather than new saving. An undertermined portion of the inflow in the first weeks after the interest-rate increase is believed to have represented funds previously loaned out on the private money market, but observers differ on how large a portion of the total this represented. The best guess seems to be that these transfers were an important part of the increase in the first few weeks, but a rapidly decreasing portion thereafter. Observers agree that the private money market has grown considerably in absolute terms since 1965,

so the growth of time and savings deposits after 1965 could not have reflected a net transfer of funds out of the private market. Very little transfer out of real assets to financial assets must have occurred, since prices of real estate and other forms of real wealth continued to rise. Any significant net shift out of real assets into financial assets would have caused a fall in real asset values.

There has been considerable discussion of the pyramiding of loans and deposits by placing the proceeds of loans into time deposits. For the small number of corporations and other businesses that pay income taxes on the basis of actual accounting records, there has been a tax incentive to borrow in order to make a deposit, since the interest cost of the loan is a business expense while interest earned on bank deposits is tax-exempt income. Such pyramiding has occurred, despite government efforts to prevent it, but has apparently accounted for only a modest portion of the growth of time and savings deposits.

Saving from Income

Even the most optimistic supporter of interest rate reform hardly expected increases in saving as large as those that followed the rise in real interest rates in 1965. Excluding annual changes in agricultural inventories, domestic saving rose from 4.3 percent of GNP in 1964 to 8.1 percent in 1965, to 12.1 percent in 1966, and 15.9 percent in 1968. Severe droughts hurt the growth of savings in 1967 and 1968, but by 1970 the adjusted saving figure had risen to 17.1 percent. Private sector saving, adjusted, rose from 3.8 percent of GNP in 1964 to 9.4 percent in 1966 and 10 percent in 1970.

Table 2 shows the constant-price growth of domestic saving by household, corporate, and government sectors from 1957. The breakdown between household and corporate saving is important to show that most of the growth of saving has been taking place in the household sector. For several reasons Korean businesses, both corporate and noncorporate, tend to pay out a major part of their profits in dividends. Corporate stockholders look for current income rather than capital gains, because the volume of trading in most stocks is so low that equities are still far from liquid and "capital gains" cannot be readily realized. Stock prices tend to be closely related to dividend levels. The tax structure also favors debt rather than equity financing, and owners look for their returns from loans to their firms at private money market rates of 40 percent to 60 percent annually. This is particularly true, of course, of firms with only a small number of owners. Only a small number of Korean firms are incorporated, but because of their size they account for about one-third of estimated private saving (as adjusted, Table 2) and receive somewhat more than half the value of all bank loans. Households (including farms and other noncorporate business),

however, account for 90 percent of estimated profits. Since unincorporated business enterprises are part of the household sector, the behavior of this sector cannot be interpreted as merely the behavior of consumers.

Table 2. Saving by sector (1965 prices, billions of won)

	Household saving adjusted[a] 1	Corporate saving 2	Private saving adjusted[a] 3 (1+2)	Government saving 4	Domestic saving adjusted[a] 5(3+4)	(percent of total investment)	Foreign saving[b] 6	Total investment adjusted[c] 7(5+6)
1956	14.73	6.94	21.67	-13.94	7.73	12.9%	51.99	59.72
1957	16.22	8.73	24.95	-15.90	9.05	15.0%	51.14	60.19
1958	22.95	11.22	34.17	-17.10	17.07	28.1%	43.78	60.85
1959	25.23	14.24	39.48	-15.47	24.01	38.0%	39.22	63.23
1960	13.87	13.99	27.85	-11.96	15.89	24.1%	50.09	65.99
1961	13.02	18.24	31.26	-10.95	20.31	28.0%	52.25	72.56
1962	6.96	26.32	33.20	-8.85	24.43	26.2%	68.71	93.13
1963	2.98	28.04	31.02	-1.88	29.15	28.1%	74.42	103.57
1964	3.07	25.13	28.20	3.82	32.02	37.7%	52.98	85.00
1965	17.18	33.71	50.89	14.02	64.91	55.2%	52.67	117.58
1966	50.07	35.43	85.50	25.76	111.26	58.9%	77.62	188.88
1967	58.43	40.71	99.13	41.55	140.68	60.9%	90.43	231.11
1968	64.85	42.00	106.85	71.97	178.81	57.6%	131.85	310.67
1969	87.63	43.85	131.47	82.67	214.15	59.4%	146.15	360.30
1970	96.54	46.05	142.60	100.56	243.16	63.6%	139.28	382.44
1971[P]	n.a.	n.a.	131.42	86.11	217.53	55.5%	174.29	391.82

SOURCE: Bank of Korea, National Income Statistics Yearbook, 1971
P – preliminary
a/ Household saving data have been adjusted by addition of the statistical discrepancy between investment and saving.
b/ Current account transfers from abroad.
c/ Adjusted by subtraction of changes in agricultural inventories.

Real (constant-price) domestic saving doubled in 1965, and then more than doubled again in the next two years (Table 2). Private saving rose by 80 percent in 1965 and by 95 percent in the next two years. Household saving showed the largest percentage and absolute increases in 1965 and 1966, grew relatively little in 1967 and 1968 because of drought and declines in agricultural production, but then increased by one-third in the good-crop year of 1969. As a portion of GNP, household saving increased from 0.4 percent in 1964 to 5.5 percent in 1966, then rose gradually to 6.8 percent of GNP in 1970. The growth of government saving cannot, of course, be attributed to the interest rate reform.

Table 3. Marginal Saving Rates[a]
(current prices, billions of won)

	Change in GNP	Change in private saving adjusted	Real interest rate (%)	Marginal private saving rate (%)
1957	45.34	2.56	-7.2	5.6
1958	9.41	3.42	12.5	36.3
1959	13.81	2.31	9.1	16.7
1960	25.69	-3.49	0.9	13.6
1961	50.13	3.46	-3.4	6.9
1962	51.76	3.14	1.6	6.1
1963	139.38	3.57	-13.2	2.6
1964	208.83	4.36	-17.0	2.1
1965	109.06	24.69	11.2	22.6
1966	226.19	45.64	17.1	20.2
1967	210.31	27.19	19.5	12.9
1968	333.30	25.65	15.0	7.7
1969	471.46	56.65	11.7	12.0
1970	498.81	49.23	8.6	9.9
1971	566.76	5.88	10.6	1.0

SOURCE: Derived from data in Bank of Korea, National Income Statistics Yearbook, 1971.

[a]Saving data have been adjusted by addition of the statistical discrepancy between investment and savings, and minus the change in agricultural inventories.

Table 3 compares average annual interest rates and marginal saving rates. When the real interest rate was 2 percent or less (1957 and 1960-64) the marginal private saving rate varied between 2 percent and 7 percent, except for 1960, the year of the overthrow of the Rhee government. At the higher interest rate levels of 1958-59 and 1965-70, however, the marginal private rate varied between 8 percent and 36 percent. When the real rate of interest jumped from minus 7 percent in 1957 to plus 12.5 percent in 1958, due to a halt in inflation (Table 1), the marginal private saving rate jumped to 36 percent in 1958 from only 6 percent in 1957. When average real interest rates increased from minus 17 percent in 1964 to plus 11 and 17 percent in 1965 and 1966, the marginal private saving rate jumped from 2 percent in 1964 to 23 percent and 20 percent in the next two years.

The low marginal private saving rate of 1967 and 1968 was almost certainly affected by the decline in agricultural production due to drought. The low marginal private saving rates after 1968, however, probably reflect the decline in real interest rates after 1967. This decline, brought about by lower nominal rates and some increase in the inflation, could have caused expected real interest rates to have

declined more than actual rates. Another contributing factor could be a decline in actual or expected rates of return on investment and therefore a decline in incentives to invest (save) in productive activities. There may also have been some lowering of profitability as the exchange rate became less attractive between 1967 and 1970, and as competition in the domestic market has grown.

Analysis of Results

A basic reason that higher real interest rates in 1965 were immediately followed by such a sharp rise in private saving seems to be the very great gap between actual market and equilibrium conditions at that time: even after the increase in bank interest rates, the demand for loans still far exceeded the available supply of loanable funds. Even the constant-price growth of bank loans by an average 31 percent annually for the next four years failed to close that gap. Investment during 1965-69 grew at a 32 percent annual rate with the aid of increased foreign as well as domestic saving. From this and other evidence it seems clear that sharply higher real interest rates in 1965 still failed to raise the supply of saving to the level of investment demand. Thus all of the increase in the desire to save that occurred as a result of the increase in real interest rates was quickly realized as ex post increases in saving and investment.

Since investment rose as fast as the growth of saving permitted, the initial decrease in consumption expenditures that necessarily accompanied the increased efforts to save did not result in a decline in income levels. Rather, the increase in investment made possible by decreased consumption demand (increased desire to save), and a simultaneous increase in the inflow of foreign saving, produced sharply rising income levels. These rising income levels further increased the absolute level of saving and possibly the rate of saving out of income, at the same time that the absolute level of consumption was also rising.

The ex ante "desire" to save is not a measurable quantity, but that it rose sharply following the 1965 interest rate reform was very evident. The new interest rates were a prime subject of conversation (partly stimulated by government advertising and education efforts) for weeks after their adoption. A majority of middle- and upper-income Koreans, when asked about the effect of the higher interest rates on their personal saving, indicated that the rates had significantly increased it. Some of the new saving was undertaken merely to add to future income now that a convenient, relatively riskless and high profit form of saving was available. Much of the additional saving was also undertaken to achieve definite objectives. The accumulation of the necessary down payment to rent, buy or improve an existing home was a frequently cited objective. Saving to buy durable goods not pre-

viously owned was another. Others saved to invest in family enterprises.

Higher interest rates on time and savings deposits provided a newly attractive financial asset for many savers, and the rise in these deposits was a substantial part of the increase in total saving. Higher interest rates also probably reduced the expected rate of inflation and made productive investment relatively more attractive, compared with real estate speculation and investment in inventory. The rapid growth stimulated by initial increases in saving and investment almost certainly increased profit rates and expectations of profits, thus further encouraging entrepreneurs to save and reinvest as much of their own incomes as possible, as well as to borrow additional funds.

Any explanation of events in Korea must consider what happens to the level of investment when the interest rate is raised. In Korea the rate of return on capital has been very high since capital has been the most scarce production factor. The real (constant-price) marginal rate of return on capital has been consistently well over 20 percent (see below), and therefore well above the real interest rate on bank credit, even after the 1965 reform. It is the gap between this real rate of return (with some discount for risk, etc.) and the real rate of interest before September 1965 which constituted the disequilibrium gap which made possible the subsequent saving and investment trends. Therefore, borrowers and investors eagerly competed for the resources freed by increased saving, and income and production rose in response to increased investment.

In more developed market economies, however, there is no such wide gap between the cost of borrowing savings (or new credits) and the expected rate of return on new investment. Interest rates are allowed more freedom to find their market-determined levels, and the cost of borrowing is much closer to the marginal rate of return on capital. Hence the consequence of a sharp rise in real interest rates in these economies (barring some temporary disequilibrium situation due to sharply changed expectations) would be to reduce investment, and therefore saving and income. This means that in attempting to measure the effect of changes in interest rates on saving and investment in developed market economies, there is an identification problem between the effect on saving and on investment.

In most developing countries, the combination of low real interest rates paid to savers in modern financial institutions and the lack of safety of funds loaned in private or traditional money market channels results in much private "saving" taking the form of accumulation of real goods, from stocks of ordinary consumer goods and jewelry to home improvement, the expansion of family enterprises and the

purchase of real estate. This type of "saving" (except for construction) does not show up as saving in national income accounts. Thus when higher interest rates attract more of the flow of new saving from accumulation of physical goods into banks or other financial institutions, the national accounts show a shift from "consumption" expenditures to saving. Whether what happened in Korea in response to increased bank interest rates is called an increase in real saving (as it is recorded in national income accounts) or merely a shift of the form of "saving" from accumulation of consumer goods to accumulation of financial assets, the important result is that a very large increase took place in the supply of saving available to finance investment in productive facilities.

The ironic aspect of the Korean experience is that, as in most developing countries, bank interest rates had been held below market levels because it was believed that this would encourage and increase investment. The actual result of these regulations, however, was to reduce the level of investment not to increase it, because of the lack of saving. Adopting a low interest rate policy in order to encourage investment is an appropriate policy for developed countries when ex ante or intended saving exceeds intended investment. Korea, however, has chronically suffered from an excess of intended or desired investment relative to available saving and credit, and what has been needed to increase investment has been higher — not lower — interest rates in order to increase the supply of available saving.

Rates of return on capital. A variety of evidence supports the conclusion that the real marginal rate of return on capital in Korea has consistently exceeded the real bank loan rate of interest. One of the most convincing indicators is the great excess demand for bank loans and the hiring of intermediaries to attempt to obtain such loans for a "finder's fee." Also, interest rates for prime borrowers in the private money market have consistently been at least twice as high as on bank loans. The large volume of loans transacted in this market to some of Korea's leading firms indicates that it is a fundamental part of Korea's capital market, and most of Korea's large enterprises borrowed substantial funds in this market prior to the interest rate reform.

Another type of evidence is rates of return to capital in the national accounts and, to a lesser extent, in two samples of individual firm data. National income data indicate that the real rate of return on new investment in Korea has been in excess of 20 percent annually, perhaps as high as 30 percent, and well in excess of real interest rates on commercial bank loans since the 1965 interest rate reform. The sample studies indicate returns of 28 percent and 24-27 percent respectively. [Detail on the evidence omitted from this extract.]

On the basis of these estimates of rates of return, the 26 percent nominal bank loan rate and 13 to 15 percent real (constant-price) rate of interest charged on commercial bank loans was considerably less than rates of return on investment. Thus it is perfectly understandable that the saving made available through the banking system following the interest rate reform was transformed into increased investment. The existence of high rates of return on expanding levels of investment reflected the very high growth rate of the economy [which also resulted from policies and factors outside the scope of this extract.] South Korea's incremental capital-output ratio of 1.7 for the 1960s is lower than that of any other major developing country. Out of an AID sample of 36 major developing countries the next lowest ratio was 2.1 for Taiwan, and only 5 of the 35 had ratios less than 2.5 Such a low incremental capital-output ratio points to a high level of efficiency in the allocation of scarce capital resources. The increased interest rates on bank loans which accompanied the higher deposit rates surely contributed to this kind of efficiency.

Inflation

Another topic to be explored is the effect that higher interest rates have had on inflation. Higher domestic bank interest rates served to create inflationary pressures by encouraging foreign borrowing and adding to monetary reserves on the one hand, but on the other generated a rise in time and savings deposits that made it possible to partly offset the effect of higher exchange reserves on the money supply. A question asked by some observers was whether higher interest rates might either perpetuate or add to the rate of inflation. What was envisioned was a cost-push type of influence; everyone had to raise prices in order to cover his increased interest costs, thus lowering the real rate of interest through inflation. This sounded plausible in a society already accustomed to a steadily rising price level. Korean price and monetary data, however, strongly suggest that this has not been the case. Rather, the growth of the money supply since 1965 seems to be a more than adequate explanation for the price increases that have occurred since the higher interest rates were introduced. The price change each year has been less than would have been expected on the basis of the growth of money supply and GNP, which has meant a steady decline in the GNP velocity of money from 14.1 in 1965 to 11.4 in 1968, and to 9.7 in 1970. Thus it seems most unlikely that the rise in bank interest rates resulted in any overall price increase; instead, it probably added to the slowdown in the velocity of money. Its contribution to the growth of investment and GNP through increased saving, and its role in limiting money supply increases through reducing net credit (loans minus time deposits) to the private sector, were important constraints limiting price increases that probably more

than offset any cost-push price effects.

An important idea suggested by Korean experience is that a realistic interest rate (in combination with a realistic exchange rate) may offset many of the growth-distorting and inefficiency-generating effects long attributed to inflation. The Korean data do show a significant relationship between the real (price deflated) interest rate and both real savings out of GNP and the real growth of time and savings deposits. If interest rates are high enough to encourage real savings and the growth of liquid assets, and to ration credit to uses having at least a fairly high rate of return on capital, then it would seem to have largely overcome the objections that inflation reduces real saving, causes people to flee from financial to nonfinancial assets, and leads to nonproductive investment. Likewise, the maintenance of a realistic exchange rate would seem to counter or prevent the usual deteriorating effects of inflation on the balance of payments. Much of the harm associated with inflation may come about precisely because it is politically, and perhaps economically, difficult to maintain realistic interest rates and exchange rates at times of substantial inflation.

Income Distribution

The major effects of interest rate reform on middle- and lower-income groups and on income distribution have probably been through its effects in slowing the rate of inflation, contributing to the growth of employment and income, and increasing the labor intensity of production techniques. In each of these ways interest rate reform added to the absolute level of middle and lower incomes and probably to the more equal distribution of income. The effect of higher interest rate income to owners of time and savings deposits may or may not have tended to skew the income distribution. Against the greater average level of time and savings deposit holdings among higher-income groups must be weighed the much more limited access of middle- and lower-income groups to high-profit alternative uses of savings. Higher-income groups were much more likely than lower-income groups to put money into real estate, the private money market, or direct investment — activities that require large sums of money or good business connections. Therefore, the proportion of assets and new savings put into time and savings deposits may well have been greater among middle- and lower- than among upper-income groups.

Applicability to Other Countries

The applicability and importance of our conclusions for economic development depends, of course, on how many countries actually have bank interest rates covering a sizeable portion of total lending

activities that are substantially below equilibrium levels. That the rate of return on capital in developing countries may be as great as suggested by the Korean data is something that has not been considered in much of the thinking about stimulating growth in developing countries. Rather, the argument is constantly made that interest costs must be kept low in order to stimulate investment. Yet recent studies on India and Chile have likewise found real rates of return on capital in the neighborhood of 20 percent.

Broader and more pragmatic evidence that developing countries do have rates of return on capital far higher than bank interest rates is indicated by the wide gap between bank rates and the much higher interest rates in important nonbank "private" money markets in all or most developing countries. An important part of business activity is financed through nonbank credit markets with interest rates at least twice as high as those of the banking system. Modern industrial firms as well as traditional goods producers regularly use such private markets. In India, for example, major industrial companies raise funds by accepting deposits at interest rates more than twice those paid by banks.

It might be objected that any kind of change in the banking system could only reach the rather limited number of people in the majority of poor countries who actually use banks for borrowing or depositing, so that an interest rate reform would affect at most a small group of rich people. Such a reform, therefore, could not stimulate widespread development except in relatively rich countries with well established banking habits. But South Korea is certainly a poor country: in 1965 its per capita GNP was less than $100 a year. Nevertheless, the striking figure for increases in the number of time and savings deposits, from 300,000 in 1965 to 6 million in 1971, suggests that large numbers of people can be induced to acquire a new banking habit: if they are offered forms of small-scale financial saving on attractive terms to replace their customary hoarding of jewelry, commodities and cash, the results can be surprising. The overall population is about 30 million, with perhaps 6 million households: obviously the 6 million time and savings deposits included numerous duplications (i. e. multiple deposits by households and firms). But this growth of deposits provides a strong refutation of the rather common pessimism concerning the ability of poor and middle-income people to save. Not only urban residents but small farmers participated; 1971 data indicate that 36 percent of Korean farmers held deposits in local branches of the National Agricultural Cooperative Federation. Once these savings are transformed into financial asset form, they can then be flexibly deployed by the banks into a variety of growth-inducing investments not otherwise attainable without dependence on increased taxation and/or inflation.

Thus the conditions which led to the success of higher interest rates in stimulating growth of saving in Korea can be found in many other developing countries. That this is so seems to reflect the relative scarcity and therefore high productivity of capital, on the on hand, and official attempts to suppress interest rates "in order to encourage investment" on the other. Given these conditions, the most rapid and efficient way to speed up investment and growth in these countries would be to raise bank interest rates for loans and deposits closer to their equilibrium levels in order to generate more saving.

[Extracted from Chapter 7 of Korean Pricing Policies and Economic Development, pp. 179-211. Baltimore, Maryland: The Johns Hopkins University Press, 1973, Copyright ©, The Johns Hopkins University Press.]

Editorial Note: The closest approaches to the Korean interest rate reform are found in Taiwan and Indonesia. The South Korean government had studied Taiwanese experience in raising interest rates in the 1950s, and then adopted this policy more abruptly and emphatically in 1965. In the late 1960s the Indonesian government, aware of Korea's experience, adopted a similar policy for a brief period, which was also repeated more recently as an anti-inflation move. In both Taiwan and Indonesia the savings responses have been strongly positive, though somewhat less dramatic than in Korea owing to the lesser degrees of stimulus.

SOCIAL ASPECTS OF URBAN HOUSING

A GOVERNMENT RESETTLEMENT ESTATE
IN HONG KONG (PHOTO: GOVERNMENT OF HONG KONG)

Resettlement Estates in Hong Kong

[The extraordinarily rapid population growth of Hong Kong, from 650,000 in mid-1945 to four million in 1972 — a result of large scale migration from China plus high birth rates — produced a large squatter population. The land area siutable for settlement is very limited, so that population density is extreme. The government has since the mid-1950s been building massive low-cost apartment blocks, clustered in "Resettlement Estates" which by now house well over one million people, and where the majority of squatters have moved — though some squatter settlements remain. Otto Golger describes the creation of the resettlement estates; Peter Hodge reviews the efforts at community development in the conditions of these densely populated apartment buildings.]

1. Resettling the Squatters

Otto J. Golger

Hong Kong, with its extremes in population density and with the excessive urbanization which has taken place over the last years, is an excellent place for studying the problems of urban squatting and the effects of planning for the housing of the poorest classes of people. While slums all over the world breed many social problems, this tendency is far less marked in the squatter areas in Hong Kong. The crime rate in the Government Resettlement Estates was 1.5 times, and in the rest of the Colony even 2.3 times, higher than in the squatter settlements (Table 1). These huge settlements were, however, a potential hazard for widespread epidemics, and for major conflagrations. Fortunately great epidemics have not occurred in Hong Kong, but major conflagrations have; between 1950 and 1954 more than 100,000 squatters were made homeless.

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Table 1: Incidence of Crime in Squatter Areas and Resettlement Estates for the Time between 1 October - 31 December 1966

	Squatter Areas[a]	Resettlement Estates[b]	Others	Total
Population	529,595	918,894	2,309,311	3,757,800
Percent of Population	14.0%	24.5%	61.5%	100.0%
Incidence of Crime	107	307	1,414	1,828
Percent of Crime	5.8%	16.8%	77.4%	100.0%
Crime Rate per 100,000 residents	22.0	33.5	61.4	50.0

[a]Includes also Resite Areas

[b]Includes also Cottage Resettlement Areas

SOURCE: Golger, Otto J., Ph. D. Thesis, Appendix LXII and LXIII

On Christmas night 1953, a fire broke out in the heart of the largest squatter area which accommodated more than 80,000 people, and it made 58,000 victims homeless. It did, however, clear 45 acres for redevelopment.

It was this fire disaster which made the government assume direct responsibility for the squatters, and the "Department for Resettlement" was created which had authority over registration, clearance and all processes of resettlement. After the great fire, thousands of homeless were living in the streets and being fed at public expense. The cost of providing relief for a family would, within half a year, equal the cost of housing the family permanently. (In January 1954, relief cost US$8,400 a day for 20,000 fire victims). Therefore, cheap, multi-storey resettlement blocks of flats were the only solution for the Government.

Today all huts of the squatters are surveyed and numbered, recording floor areas, heights and intended uses of rooms. The aim of the "squatter control" is to keep the area "frozen," which means that any new structure or extension to a tolerated structure will be demolished. When an area is required for development, the squatters are informed some months ahead and then they are moved to new resettlement estates, which are, unfortunately, often located in another part of town. This

inevitably means new schools, neighbors, friends and shops — a whole new environment. According to a 1967 survey, an average of 40. 6% of the squatters interviewed do not wish to be resettled at all — a figure that surprised the Department for Resettlement, which considered that more than 90% of them would prefer to be resettled (Table 2).

Table 2: Attitudes of Squatters towards Resettlement in Squatter Settlements under Survey for 1967

Subject	Average Household
We should like to leave if the R/E is within this district (or only if it is nearby).	42. 8%
We should like to leave even if the R/E is far away (across the harbor even).	16. 6%
We should not like to leave at all. (We like to stay here.)	40. 6%

Besides the lack of communal facilities and fresh water supply, the lack of sufficient and proper toilets are the biggest problems for the squatters. For children, however, this village-like environment and the security of a neighborhood is really comforting. There is little fear of burglars and most parents would let their children play even far away from their huts — quite contrary to the inhabitants of the resettlement estates, where none of the parents interviewed would let them play on the allocated playgrounds far below. The author's research in Hong Kong showed that the main problem of squatting is the lack of proper public facilities (schools, out-patient clinics, community centers, markets, recreational facilities, etc.), as well as the lack of fresh water supply, electricity, drainage and waste disposal: in a word the lack of a planned infra-structure.

Resettlement Estates

According to the plans of the Hong Kong Government the hundreds of thousands of squatters should be gradually resettled into multistorey resettlement estates. These huge estates have attracted world-wide attention since they are unparalleled in the capitalist world, and can be considered the world's biggest housing scheme outside the socialist bloc, comparable only to a certain degree to the public housing program of the Singapore Housing & Development Board. By 1969, already, more than one million tenants or over a quarter of the population, was living in 23 estates, with a planning target of 1. 9 million by 1974.

These estates are, by the standards of other countries, fantastically

overcrowded. The Mark 1 standard size for flats was 120 sq. ft. each. (Mark 1, 2, etc. are names of the designs for apartment buildings in the estates.) This meant floor space for 5 adults, or 3 adults plus 4 children (they are considered children until their 10th birthday), with a net floor space rate of 24 sq. ft. (2.2m^2) per adult. From 1964 onward, both the Mark 1 and the improved Mark 2 designs were abandoned because of the poor standard of accommodation. Today, mainly 16-storey high Mark 4, 5, and 6 types of blocks are being built, differing fundamentally from the older design in that access to the flats is from a central corridor on each floor (Figure 1). Each flat has its own private balcony and private toilets as well, with light and power points installed in each domestic room. The standard floor space is still 24 sq. ft. / adult, later improved to 35 sq. ft. (3.3m^2). There are refuse chutes and two elevators, which stop only at the 6th, 10th and 14th floors and on the 8th, 12th and 16th floors respectively.

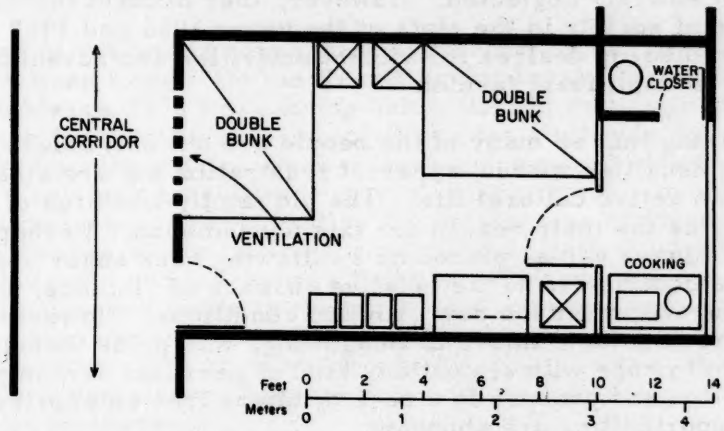
Table 3: Occupations of Heads of Households by Type of Housing in 1968

Occupation	Squatters	Resettlement Estates	Private Tenements
	%	%	%
White Collar	4	9	24
Skilled Manual	6	5	6
Semi-skilled Manual			
a. Traditional (e. g. hawker)	36	23	30
b. Modern (e. g. factory worker)	23	31	9
c. Service (e. g. barber)	8	8	5
Unskilled	19	17	21
Unemployed	4	7	5
Total	100	100	100

SOURCE: Hopkins, Keith; "Public Housing Policy in Hong Kong," University of Hong Kong, Supplement to the Gazette, Vol. XVI, No. 5, 1969, Table 4.

For such a new 16-storey resettlement block it took, in 1967, only 12-16 days to complete one floor by application of the all-load-bearing walls system; whereas previously it took 22 days using a frame structure, and also more concrete to complete the same volume of construction.

It takes about 9 months to finish the rough work and 16 months to complete such a building, including all fixtures and the finish. The floor-to-ceiling height is 9'6", the ceiling is 4 1/2" reinforced concrete, without sound insulation but with a cement screed on the floor. Rooms are 11' 0" wide and the reinforced concrete walls are 9" thick. Structural prefabricated elements are not used at all. The costs of site preparation, roads and drains are about 7-10% of the total expenses. The construction costs of a unit of 120 sq. ft. (for 5 adults) in 1966 was about US$700, only 40% of the price (US$1,700) of the cheapest privately built accommodation of the same size.



A Mark 4 unit in Chai Wan Residential Estate

Social Aspects of Resettlement

For the government, the resettlement program has been a great success, both as a building program and an administrative process of moving hundred thousands of people into new housing. However, the resettlement estates were never meant to be more than a relief of the most severe pressure on the sub-standard housing conditions.

The resettlement of large groups of people inevitably affects their attitudes. To live as squatters is the people's own (although most likely their only) choice; but the moment another way of life is imposed on them they are likely to blame some of their problems on the authorities responsible. In the impersonality of huge housing estates, individuals can escape the close social control of neighbors exercised in traditional villages and in the squatter settlements. Many of the estates also lack proper communal facilities such as schools, clinics, kindergartens, post offices and recreation grounds. Although these enormous housing estates offer some of the basic amenities necessary for Man as a biological species (such as shelter, water, electricity,

and a latrine), for Man as a social being or as an individual no provisions are made. The main problem is not the living conditions, nor the great number of people. It is the poor social environment with its lack of communal or recreational facilities, the inflexibility of the standard-sized flats and the lack of "psychological space."

A particular social problem of the housing estates are the older children. The only places for the youngsters are the streets between the huge blocks; there are no meeting places and no places for being alone in this planned environment; the organic needs of young people were almost entirely neglected. However, they brought themselves to the notice of society in the riots of the years 1966 and 1967 when all their dammed-up desires for violent activities and adventure were released in an unpleasant fashion.

It is amazing that so many of the people are not only able to survive at such high densities without apparent frustration but are also capable of creating an active cultural life. The old family tradition of the Chinese may be the main reason for this phenomenon. Perhaps the traditional Chinese values placed on swallowing back anger and avoiding conflict have contributed to the relative absence of violence, in both the old slums and under the new crowded conditions. However, not all people are like the Chinese in Hong Kong, who pride themselves on being able to cope with almost any kind of personal hardship so long as they can live and prosper in a society where free enterprise and individual opportunities are abundant.

[Extracted from "Hong Kong: A Problem of Housing the Masses," Ekistics, No. 196, March 1972, pp. 173-177. Athens, Greece: Athens Center of Ekistics, Athens Technological Organization. The article was based on the author's Ph. D. Thesis for the University of Hong Kong.]

2. Community Development in Hong Kong

Peter Hodge

A housing "estate" in Hong Kong is the equivalent of a moderate sized town elsewhere. The population of Resettlement Estates range, for example, from 67,000 at Shek Kip Mei to 170,000 at Tse Wan Shan. As the design has been modernized the estate blocks have grown larger. Mark 1 and Mark 2 blocks were eight storeys high and housed around 2,000 persons. The Mark 5 blocks are sixteen storeys, and the Mark 6 blocks twenty storey high, housing about 5,000 to 6,000 persons.

Shortage of space and consequent overcrowding has been a perennial problem in Hong Kong. On the Resettlement Estates some 300,000 persons in March 1970 were living below the old minimum standard of 24 square feet per adult. Out-of-doors the clutter is just as great. Most of the housing estates were narrowly conceived simply as cheap housing. They lack amenities — parks, playgrounds, markets and shopping precincts. Consequently, the estates are cluttered with illegal structures where hawkers conduct their daily business, and many restaurants and tea-houses flourish. Indeed, there is no alternative to the hawker stalls in the absence of markets and shopping areas, for how otherwise would the daily shopping be done? And in the older estates, with no kitchens provided and cooking having to be done on the open balcony, breakfast in a large family has often to be taken in the tea-house.

Although technology enables more and more people to be housed on the same land area, the sheer size and density of population is a most baffling factor facing every agency contemplating community development in such a setting. Where, for example, is the "neighborhood" in a block twenty storeys high? What are the effects of the stress and pressures of living in the concrete human ant hills of Hong Kong? There are impressionistic accounts of alarming noise-levels, increasing delinquency and crime, formidable problems of dirt and rubbish, and evidence of public indifference to the squalor in the environment. In July 1971 the Commissioner of Resettlement noted that parents were keeping their children at home to watch TV and not permitting them to go out to play and mix with others of whom the parents were suspicious, and were apprehensive in case children's squabbles led to animosity with the neighbors and unwanted involvement.

The government is concerned over the absence of a sense of belonging to Hong Kong and the lack of a feeling of identity with the com-

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munity. Many people who were refugees from China two decades ago still hope one day to return to China, and have expressed this to the Social Welfare Department who want to help groups and communities to form themselves out of unrelated individuals or family units. Social welfare services, it was hoped, would help people on the Resettlement Estates to develop community feeling, to be "at home," and so to evolve into stable units. Two approaches were adopted by the Social Welfare Department.

Kaifong Welfare Associations

In the 1950s the Social Welfare staff revived the Kaifongs and helped them restore their charitable and relief functions in the community. Kaifong is a Cantonese expression meaning residents of a particular street or locality. Traditionally they had very practical social responsibilities — repairing bridges, mending roads, promoting schools, providing free medical aid for the poor and free coffins for the indigent dead. The Japanese Occupation in 1942-45 killed all but the remnants of one; but by 1954 there were over 20 recognized Kaifong Welfare Associations with a membership of about 250,000.

Their work took up the old tasks of opening and running free schools for poor children of the district; providing free medical attention by Kaifong members who were either herbalists or Western-trained doctors; organizing sports activities; setting up domestic training and sewing classes for women; offering free maternity aid. The importance of the Kaifongs as welfare agencies declined as government itself provided more schools, medical services and social welfare services, and took a more active part in community development after 1960; yet the Kaifong associations continued to grow. They numbered 54 in 1969 and claimed a total membership of over 850,000. However, the character of the Kaifongs changed, and they assumed more political functions by actively promoting government policies for educational and recreational work amongst women and youth, and by organizing community campaigns for health, public hygiene and road safety. The Kaifongs continue to confer status upon their leaders within the Chinese community. But a traditional leadership does not attract the support of the younger generation.

Community and Social Centers

A second approach used by the Social Welfare Department was through the community center. Finance was made available with the World Refugee Fund in 1960 for four community centers to be built in Resettlement Estates, and they were constructed and opened between 1960 and 1966. The Social Welfare Department also opened two social centers, one of them in an old urban area of the city of Victoria. Through a variety of clubs for men and women, youths and children,

friendship groups, sports and interest groups, library service and meeting places, it was hoped that the centers would become a focal point for community activities, and attract the active participation of local residents. Each center was also used as a base from which an outreach program of contact, home visiting, and referral service might be offered to people living in the neighborhood, and thus stimulate self-help endeavors.

A careful study of these four centers in 1970, however, found them failing to measure up to the community development rhetoric of the annual reports of the Social Welfare Department. The community centers offered services of the traditional youth club type, and 60-70% of the members were aged between 5 and 19 years. About 45% of center members came from Resettlement Estates closest to their center, and the buildings did appear to serve the residential districts they were designed to. The study found "no evidence of community centers encouraging the formation of organizations which might be critical of government" – assuming that community development promotes the growth of groups having civic responsibility and concern for improvement and change. Only a small percentage of community center members were active in organizations outside of the centers, and these tended to be school or recreational groups.

The Hong Kong experience of community centers reflects the same situation as in a number of other countries. They were imposed from outside the local community, and could hardly be considered to be products of local effort. They are not managed in any real sense by people of the local community. Because the Kaifongs were always considered to be at risk in the early years from exploitation by triad (secret) societies and undercover political agents, so the community centers appear to be kept under tight political and bureaucratic control, and are regarded more as tools of social control than of social change.

District Officers and Community Development

A City District Officer scheme launched in early 1968 was designed to provide an officer in an urban district whom the residents could recognize as "the government" in their district and who, on his part, would gather opinion and judge popular feeling on local issues. In the language of a first progress report published on the scheme after just over one year of operation, the City District Officers were to: "make themselves as accessible as possible to the people in their districts, and keep in touch with all local organizations. In addition to assessing the overall impact of government policies they are required to explain these policies as well as the difficulties and the achievements of the government to ordinary people. They do not have extensive executive functions but it is part of their duties to advise on the coordination of

of services. They are free to consider whether there should be any variation in emphasis in government policies in the districts and they may initiate proposals for new policies or new procedures when the need for these becomes apparent from the feeling of the public. They are expected to become aware of problems and conflicts and trends of public thinking before attitudes have been struck. They are there to receive complaints, representations and personal problems arising from any Government activity.... It is thought that City District Officers can assist those suffering from a sense of grievance to present their cases coherently and, when necessary, to act as their advocate."

The scheme appeared to be the old paternalistic figure of the District Officer transferred to an urban setting. [These officers are the chief officials for civil administration in their districts; their careers are in the department of Home Affairs, which is concerned with maintenance of law and order.] In fact, the scheme was as useful to the government in propagating its policies as it was for discovering firsthand the different problems faced by the people in each of the ten districts into which the urban areas of the Colony were divided. The success of the scheme has been helped by the choice of the officers concerned and by their ease of access: all of them operate from walk-in shop-offices in the main streets. The number of cases and enquiries handled by the officers increased considerably since the inception of the scheme: 1968 — 135,297 cases; 1969 — 362,807; 1970 — 647,832. The nature of the enquiries varies from time to time, but in the first half of 1971 they were concerned with applications for Housing Authority estates, government posts, admission to the Technical College and Technical Institutes, rent increases, and applications for accommodation on Low-Cost housing estates.

Nevertheless, when the City District Officers came to stimulating self-help and liaison with Chinese organizations, clubs and groups, they were faced by the problem of the size of their district. One officer, for example, operates in Mongkok, a congested district of Kowloon where "300,000 people live, and where there are 350 organizations and societies, 90 schools with an enrollment of 64,000, some 3,000 hawkers, 8,000 boat people, and 850 multi-storey buildings." There is much talk of deepening and broadening a continuing dialogue between the government and the people through the instrument of the officer. But these government officials are extremely sensitive to the potential for community development groups becoming organized pressure groups of complainants protesting any weaknesses and shortcomings of official policies, for example, in housing and town planning; and a genuine concern with grassroots popular participation is to be doubted.

District Community Officers (DCO). A parallel scheme, sponsored by the Social Welfare Department, has been the appointment of District Community Officers who are professional community workers (rather

than law-and-order administrators). Four such officers were appointed at the outset in February 1969. The hope was that in those city districts where they were appointed, the DCO's and the City District Officers would work together in developing services for the community and with the help of local people. But conflicts have arisen between them, and the DCO's have felt, with some justification, secondary in importance in the districts. The DCO's were regarded as experimental appointments, and the expansion of their number hangs on a high level policy decision as to which department, the Secretariat for Home Affairs or the Social Welfare Department, will promote community development. As community development is regarded as a political exercise, the City District Officers are skeptical of the ability of social welfare staff to handle such complex and delicate matters. Little impact on street-level community development has been made so far by either type of officer. Growth of this work has been mainly in projects sponsored by voluntary organizations, notably Church-supported bodies. City District Officers and District Community Officers have tended to busy themselves in coordinating groups of traditional community organizations, such as the Kaifongs, and smoothing the way for inter-departmental cooperation. Spontaneous community groups have refused to be involved and have shown an independence of spirit, wishing to avoid the embrace of both types of officer with their proclivity to take over affairs.

Community Development Projects

Sau Mou Ping project. A handful of projects have been carried out in Hong Kong in recent years of which two are of interest. The Sau Mou Ping project involved staff members of the Social Welfare Department and students from the University. In essence, the project attempted to discover whether it was possible to reach out and contact residents of a Resettlement Estate in their own environment, and to help residents identify common problems in living together and to find and use resources, especially their own, in overcoming their problems. An experienced community worker acted as a catalyst on the estate.

Various groups emerged from the project: a women's group, an old people's group, a children's club, and a community health scheme to encourage people to take the cholera vaccinations and to solve the problem of dirty and insanitary communal staircases by organizing work-parties for regular washing of the staircases. A tuition scheme was also arranged for helping school children with their homework, and for a time a tailoring group of women met for instruction. One important conclusion of the project was the value of having a worker attached to each estate block to offer continual service to individual tenants, at least until groups of tenants could be formed to begin to manage their own affairs. Such a worker might best be a member

of a team working in a small area of a district, under the guidance of a District Community Officer.

Caritas project. A second project on a Resettlement Estate based on Block 20 of the Tung Tau Tsuen estate began in January 1970. The area is near the old Walled City of Kowloon which has been the scene of much crime and drug-taking and is the same place which witnessed the outbreak of the 1967 riots in Hong Kong. The block chosen is an old Mark 2 block with a population of about 2,700 (100 elderly, 800-900 adults, 1,000 youth, 500 primary pupils, and 200 below primary). The majority of the adults are laborers, including factory workers, hawkers, and people running home-factories in the block itself. The average level of education in the block is very low, and of nearly 1,000 young people of secondary school age only about 30 are in secondary school. Three different dialects are spoken, not reciprocally understood, scattered throughout the block, each representing about one-third of the block population: Cantonese, Tung Bun and Chiu Chou. The tenants shared common toilet facilities and a common water supply, and suffered from lack of space, noise, dirt, and the problem of drug addiction in their midst.

The Caritas project did not begin with the established leadership in the community, that is, the church, school and social welfare agency leaders. It began with the people in the block, where they were, and with their own needs, opinions and feelings. Three community groups emerged during the first year, meeting regularly to discuss and act on problems of common concern. A group of mothers were concerned about the poor school performance of their children and the high number of school drop-outs, and decided to run a study program for them. They negotiated for the use of a roof-top classroom in Block 20 and arranged amongst themselves to take charge of the room and give supervision. Another group of young factory workers cleaned, painted and furnished a community room for their use, and cleaned up an adjacent open courtyard to be used for recreational activities. A men's group formed for the enjoyment of playing and listening to Chinese music. Nearly all of these people were residents of one block, and seemed interested mainly in their own group, and had little concern for other blocks or for the community as a whole.

During 1970 the various Caritas workers learned that it was not feasible for community workers to have any direct connection with room control nor with money to subsidize projects. A community worker, according to their own evaluation, is not there "to give money, things, or service; he is there to stimulate, to mobilize, to help people think through problems and to take responsibility for them." The staff did not find the unstructured situation and the newness of the approach very easy. But despite the difficulties, young people from various walks of

life were attracted to the challenge of the work, and a group of dedicated volunteers has emerged.

In 1971 the project extended from Block 20 to two additional blocks on the Estate. A trans-block concern was the lack of privacy in common bathrooms through the absence of doors, on washing cubicles, and the incidence of sexual assault. Other issues on which the people of more than one block came together to work concerned the tuition program for their children, and the collection and disposal of garbage. After 1971 the original plan for the project was changed. In the future, each worker would continue to concentrate on individual blocks and the residents' development within each block; but as individual blocks matured around certain issues, trans-block unity around issues was to be the focus of effort. Common issues had become important as a uniting bond, rather than the traditional role groupings such as mothers, factory workers, etc. Residents, however, had to show readiness in their own individual block for common action upon common concerns before joining with residents of other blocks. Experience in 1971 also revealed that after a period of about a year in a block a community worker can take responsibility for more than one block. Early in 1972 some four full-time workers and three part-time workers were working with 18,000 people.

Both the Sau Mou Ping and the Caritas projects have demonstrated the need for intensive work at the beginning with a community worker based on an estate block. It is still uncertain what the next tier in the 'structure' should be, between the block and the estate, and beyond that, the district. Workers operating in a team from one agency can make contacts with and support groups in a number of contiguous blocks, but whether tenants' groups in those individual blocks will themselves freely come together in some form of link-up association remains to be seen.

Community Action

In a densely populated city like Hong Kong most schemes of urban renewal and development involve upheaval and removal for some persons, and the disturbance of a way of life. On several occasions in 1971 "issues" have arisen to unite groups of people to oppose changes which did intimately affect their way of life. For example, for the extension of Kai Tak Airport, a mass of earth and stones had to be stockpiled nearby. In August 1971 dozens of earth-laden lorries of a Japanese contractor raced incessantly day and night from a quarry collecting point to the seaside at Hung Hom, close by a large Resettlement Estate, spilling dust, emitting fumes, and causing noise, pollution and nuisance. The residents of the estate became very angry when their protests to the lorry drivers achieved no results, and the residents began throwing stones and threatened personal attacks on the drivers.

A community worker, based on a local parish church, helped the people to form an Anti-Dust Ad Hoc Committee, who met the Kowloon City District Officer who arranged for them to contact appropriate government agencies. The Public Works Department got the contractor to suspend lorry traffic from 8 p. m. to 8 a. m., enabling the residents to have some quiet sleep, and the contractor agreed to employ water trucks to spray water on the streets, and to hire two laborers to sweep away spilled dirt three times a day. These were ameliorative measures, not completely satisfactory, but a formerly disinterested community began to realize that they could tackle their own problems if they worked together collectively. Consequently, later in the year they were in a stronger position to deal with another environmental problem when it arose: blasting of a hill near to the Tai Wan Shan estate shattered apartment windows, and hurled dust and fragments of rock into the estate grounds, killing a dog. The contractor had failed to put up a protecting bamboo and matting screen, as is customary on demolition sites, between the blasting operations and the estate buildings. Another ad hoc residents' committee was organized to deal with the problem of safety and nuisance, and to protest to the contractor and responsible Government departments.

Conclusion

This survey of the range of approaches to urban community development in Hong Kong reveals nothing startlingly new. Hong Kong may represent an extreme case, however, with its shortage of land space and its densely populated streets and estates. A large percentage of its people have been settled in public housing schemes, which created huge ghettos of a uniform class of poorly educated, unskilled and low paid factory workers, street hawkers and laborers. In such conditions, the attainment of a sense of community and its articulation face special difficulties.

In Chinese culture the tradition of avoidance of officialdom and of hesitation or reluctance even to seem to disagree with persons in authority, whether in the government or in the voluntary agencies, has had its effect on all types of community work. In voluntary social welfare agencies especially, community organization has been over-dependent upon power-figures drawn from the elite of the community. Generally this has been by choice, since many Chinese seem to prefer directive methods of work and select elitist figures for leadership roles who, as in the Kaifong associations, have first of all to measure up to specific status requirements and proven achievement in business or commerce.

Where changes have occurred, where people have been found to be genuinely interested in having a voice in working together towards solving their problems, the results have been encouraging; but the scale of

operations and change remains small. The passage of the Multi-Storey Buildings (Owners Incorporation) Ordinance of 1970, for example, has stimulated owners of flats in multi-storey blocks to organize themselves to provide for the management and maintenance of their buildings. A number of owners and tenants associations have been formed and have set up management committees; but these have been mainly in middle-class housing areas. For the low-income housing, especially the Resettlement Estates, a former Commissioner of Resettlement recommended the setting up of internal self-government through councils of tenants. The Commissioner felt that Hong Kong should look forward to Resettlement Estate Councils elected by the residents themselves with powers, like municipal councils, to manage their own schools, organize their own cleaning services, regulate hawker areas, and maintain their own community centers. Such apex bodies might be served by the smaller, block-level associations already coming into existence.

Whether such councils would work as true expressions of popular participation and mutual aid will depend on the degree of loyalty and support they can evoke. This depends partly on whether the ordinary people of Hong Kong can acquire a sense of belonging to the place where they live. Hong Kong co-exists with an enigmatic neighbor, China; the future is left deliberately opaque. With this state of affairs the older generation seem quite content, but the young people are less so as they grow increasingly proud of being Chinese and wish to bring some certainty into their future. In this context, community development can deal with mundane, practical problems — garbage disposal, broken water pipes, evening classes for backward children — and let the intangibles alone. Indeed, there is much to be done along these lines; but one cannot predict whether such concerns will or will not be overshadowed by others of a more political nature.

[Extracted from "Urban Community Development in Hong Kong," Community Development Journal, Vol. 7, No. 3, October 1972, pp. 154-164. London: Oxford University Press, Copyright©, Oxford University Press.]

Types of Government Housing

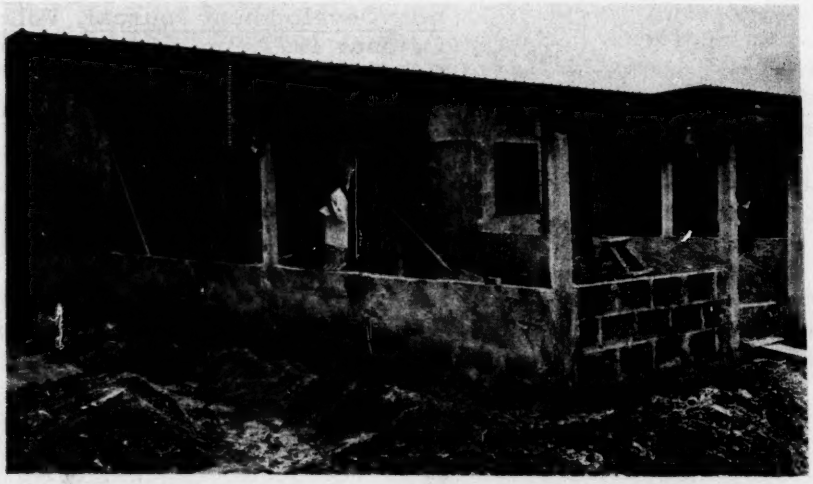
Apartment complex, Lagos, Nigeria
(Photo: Courtesy of Taofiq, Oseni, Nigerian Embassy)

(At center photo)

Individual Housing, Argentina (Photo: USAID)

(At bottom photo)

Row Houses, Ivory Coast (Photo: USAID)



Slum Clearance in Lagos

Peter Marris

[Slum clearance programs which move people out of environments adapted to their needs for security, job and trading opportunities, and kinship ties can have destructive consequences when the new environment fails to meet these needs. People's needs differ, as do the conditions in new housing projects; but when the two are relatively incompatible, as in the case analyzed here, the results can be unfortunate.]

The reactions of people who are moved from one place to another in programs of slum clearance run all the way from eagerness to escape the slum environment, through transient nostalgia, to lasting grief over their displacement. If we can understand a change of home as a potential disruption of the meaning of life, we may be able to see more clearly who will suffer grief, and what might help them to retrieve a sense of purpose. For some, rehousing will represent the realization of a social status and way of life with which they already identify. For others it will be, once the strangeness has worn off, a recreation of what they valued in their former neighborhood. But for some, it may be a profound disturbance from which they never recover. And such tragedies are, I believe, more likely the more that slum clearance is used as an instrument of social change, not merely of physical development; and the more it is directed against groups in society whose nonconformity with the ruling values seems to stand in the way of progress.

From this point of view, the slum clearance scheme I studied in Lagos, Nigeria, was an object lesson in the inevitable frustration and cruelty of exploiting

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housing as a means to more fundamental reforms. Not that the redevelopment authority was unconcerned with the social implications of its plan. It had to answer repeated protests against the hardships it caused — by breaking up family groups, isolating old people, bankrupting businesses disrupted by relocation — and tried to relieve them. Nor were the residents it dispossessed unresponsive to the need to adapt and change their city. They had long acquired the city dweller's skill in improvising their own use of buildings designed for another purpose. But if we trace how traditional relationships had evolved in modern Nigerian society, it becomes clear how sensitively the old parts of the city incorporated both traditions and modern realities, despite some ambiguities; and how discordant was the design of the rehousing estate. In particular, the redevelopment scheme implied a radical reinterpretation of the meaning of marriage.

Marriage and the Streets of Lagos

Central Lagos expressed, in the use of its spaces, a distinctively Nigerian response to the opportunities and risks of life in a commercial capital. The way people understood the obligations of marriage, their corresponding emphasis on wider bonds of kinship, and the importance of a wife's earnings to the viability of this pattern of relationships, represented together an adaptation of pre-colonial society. As marriage lost the protection of some traditional sanctions, women sought other guarantees against abandonment and hardship, which only gradually and largely unconsciously changed its meaning. The slum clearance scheme disrupted this subtle evolution, as can be seen among the Yoruba who were the majority of inner city residents.

Traditionally, when a girl married into a Yoruba family, she took her place in a hierarchy of status, assuming rights and duties, not only towards her husband but his whole family. As a bride, she was inducted into the patrilineage: she lived in her husband's compound, subject to the authority of its head, and deferred to her seniors. Her conduct was important to them all, for the future of the line depended on the children she bore them. The marriage was protected by a pledge between the two families it joined — the bridewealth paid by the husband and his kin. Despite the emphasis upon the patrilineage, a wife retained rights within her parent's family. For both men and women their economic security, political status and social identity were determined, not by any single relationship, but by their membership in kin groups as a whole. Marriage defined where children belonged, but the relationship between husband and wife was not itself expected to express any particular intimacy or intensity of emotional loyalty, especially since a man might have several wives. In Lagos, if men and women idealized any sentimental attachment, or expressed a predominant personal loyalty, it was above all to their mothers, and sometimes to a brother or sister of the same mother close to them in

age. Beyond the immediate household, the kin group as a whole commanded the over-riding loyalty.

This tradition rested upon the stability of tangible rural economic assets — the family compound, with its many rooms arranged about a courtyard, which guaranteed shelter; the family land, which guaranteed a livelihood and an inheritance for its children; the bridewealth, which guaranteed collective responsibility for marital conduct. But none of these held the same power of sanction in an urban money economy, where people mostly rented accommodation and worked for a wage. Rights in land or a family house in another place were of little use to a trader, clerk or laborer.

Though the family no longer controlled so exclusively the means of earning a living, it still provided most people with their only security. Some long-established Lagos families maintained a house which remained the headquarters of its affairs: elderly relatives found shelter in its rambling courtyards, the head of the family and some of his married sons occupied the principal rooms, and the family councils were held there. But families which owned no property settled in rented rooms in the same compact neighborhood, exchanging daily visits. Everyone had family affairs continually in mind, and in the cool of the evening would make the rounds, passing news, discussing problems, bringing a present of food for an elderly aunt or a shilling for a favorite nephew. The family would meet more formally once a week, or once a month, to review the needs of its members and arrange how to meet them. Money would be raised, according to the means of each, to pay a doctor, educate a child, support someone out of work; the family network would look out for a job for a newcomer or find him a place to live; disputes would be arbitrated. Few people had such secure and well-paid posts that they could afford to neglect this system of mutual support; and these few held such authority in it, and contributed so much that they could not honorably withdraw.

Thus the collective solidarity of kinsfolk remained the crucial insurance against hardship, but it no longer offered much protection to a marriage. The bridewealth had become a trivial sum compared with the former expenses of a proper wedding, and a man might find it from his own savings. Few bothered to reclaim it if their wives left them, and some parents no longer asked it, preferring the money to be spent on their daughter's welfare. More and more men found their own wives and married without any formal arrangement between the families, even without asking their parents' consent. A wife who lived with her husband in a rented room and did not claim on their property, who cost them nothing and whom they had not chosen, was not of much concern to his kinsmen, though her children would be. She could no longer be sure that if she complained to her husband's family, her case would be fairly listened to in his family councils.

She depended more than in the past on her own parents, brothers and sisters.

Marriage, therefore, was not now an alliance between two families, but between a man and a woman whose most compelling loyalties were still to the families in which they were born. It could provide a woman with only fragile security. Her husband might fall sick, lose his job, or desert her for another wife, and in these misfortunes the goodwill of his family was uncertain — especially if the match was not of their making. As an insurance against such risks, and to contribute to the needs of her own kinsfolk, she wanted an income of her own. So it became a custom in Lagos, as part of the marriage agreement between a couple, for a husband to provide his wife, as best he could, with money to capitalize a petty trade, to learn typing or dressmaking, or set up a shop. She was not expected to contribute these earnings to the household expenses: and if she sometimes did so when her husband was in want he acknowledged her generosity. This independent source of income became crucial.

The kinship system adjusted by a more even balance between the claims of a man and woman's lineage. Trade or job became a more central preoccupation of women: if they were forced to choose between their husband and their economic interest, their own earnings often promised a more dependable support. Marriage was a contract of iimited obligations: to bear a man children and keep his house; to pay the housekeeping allowance and finance a woman's livelihood. The wife's obligations to her kinsfolk and her occupation now competed with her husband's claims. The success of the marriage relied on mutual respect for the independence each partner needed to retain.

The streets of central Lagos reflected this pattern of life. The narrow alleys were crowded with women hawking their wares — bolts of cloth, cola nuts, cigarettes, tins of groceries — balanced in baskets on their heads; grandmothers traded from their doorsteps, as much to be part of the life of the street as to sell their few dusty articles; dressmakers bent over sewing machines on the porches of the houses; cooks tossed fried cakes over charcoal braziers for the clerks from the city offices. All day and late into the evening people passed to and fro to work, to the great markets, to negotiate a business deal or visit relatives and friends. The houses huddled together in an irregular mosaic of courtyards and passages, their dark and overcrowded rooms opening onto spaces where women cooked and washed, children played, men talked. Some rooms would be occupied by the members of a lineage, whose head, perhaps, conducted his business from the front parlor; others were rented out. For tenants and owners alike, their family connections branched through the neighboring streets, so that as they came home from work, or school or market, they called on grandparents, aunts, parents, brothers and sisters, cousins, ex-

changing greetings, making small gifts to the elderly, passing news. By the layout of its dwellings, designed not for a single household but a group of related households; by the intermingling of domestic life and petty trade; by the compactness of the clusters of family networks; by the indifference to the amenity of the cramped and sparsely furnished rooms, which provided parents and children with their only intimate private space; by the gregariousness of its streets, central Lagos expressed faithfully the values and meanings of the lives it sheltered.

The Rehousing Estate

The rehousing estate embodied a profoundly different conception of life — a cut-price translation of English suburban homeliness. The neat terraced cottages were designed for a single household: kitchen, living room, bedroom leading off each other in an integrated pattern which two families could not suitably share. Street trading was forbidden, and besides, the roads were empty and lifeless, as people dispersed to the city for the day. Commerce was segregated in a shopping center. The nearest places of employment were several miles away. Even if the amenities of a suburban home had appealed to them, they could not afford the cost in fares, the rent of space, the higher price of food in local shops. Craftsmen and traders lacked the resources to capitalize a modern workshop or grocery store, and survive months of poor business in the hope of creating a market: most went bankrupt, or returned to the city.

Life on the estate imposed a reallocation of resources from the claims of kinsfolk, now scattered and less obtrusive, to the maintenance of a private household in dignified surroundings. And this symbolic emphasis on the separate married couple as the relationship above all to be enhanced and protected was not only beyond the means of most people, but meaningless. They could understand the value of less cramped quarters and more solid building, but these amenities were trivial compared with the sacrifices they entailed. Old people became isolated, their needs unnoticed: a nephew who could afford to give his aunt sixpence could not so readily spend twice as much to ride the bus to visit her. Family councils lapsed as their members dispersed. The people of central Lagos were unused to the means by which social contacts are maintained across a distance — letters, telephone calls, visiting by appointment, tracing addresses from street names and numbers, the ordering of time to complement the segregated ordering of spaces.

There were, however, Yorubas who had rejected, in varying degrees, the values that were accommodated in the old environment. Kinship did not control their economic opportunities or receive their rewards, however much their relatives struggled to secure them for the benefit

of the family as a whole. The ablest and most fortunate were no longer dependent on the solidarity of their lineage. Family loyalties continually claimed upon them, sometimes exorbitantly; but secure in permanent, pensionable, salaried posts, they had no reciprocal demands to make. Their children's future would be determined, not by the rights of lineage, but by educational qualifications: and the more they restricted the scope of their obligations to kin, the more readily they could pay for good schools and study overseas. A new middle class was emerging, for whom the inherited loyalties of kinship contradicted their economic interest so long as both rich and poor remained one family. The physical structure of the old city disguised this class distinction: the rambling family houses with their dark, shabby rooms had nowhere to display personal wealth, while the claims of kinship obtruded everywhere. At home, it was hard to tell a rich merchant from a laborer: both wore the same singlet and frayed khaki shorts, sat on the same wooden stools, and slept on the same bed of hard cords. Wealth showed in open-handed hospitality and authority in the family councils. Many of the younger men, especially, struggling to secure their middle class status, felt trapped by these pressures. Support for relatives ran them into debt, their children's education was still to pay for, and they had begun to see a disreputable, backward squalor in their surroundings.

The rehousing estate catered to these discontents. It embodied the aspirations of the socially ambitious, and helped to defend them. Here a young clerk could furnish a parlor with a bookshelf and radio and study his correspondence courses in peace, secure that dunning relatives would seldom find him. His wife could serve tea and biscuits and keep the children at their homework. To the estate's planners, this was the intelligible pattern of progress, and they set out to serve it. They were not insensitive to the hardships of rehousing, and would have liked to relieve them; but they could not compromise the underlying conception.

The reformers' argument for slum clearance projects begins with the premise that physical squalor is an affront to the order of society. Crime, drunkenness, prostitution, feckless poverty, mental pathology do indeed cluster where housing is poorest (though not there only). Bad housing thus becomes a symbol of complex discordances in the structure of society and is treated as if it were a cause of them. In this way, society hands its most intractable problems to professional administrators, who accept the ideals which underlie their assignment, but are neither trained nor required to search out the social implications. The Lagos Executive Development Board must have been vaguely aware of the nature of marriage in the city and the importance of petty trading to it. They knew the tradition of kinship and the part it played in social insurance. But they were not obliged to work out how these patterns of relationship inhered in the old city and confront the impli-

cations. Their practical task was constrained by more urgent considerations of land prices, subsidies, rent income, building costs, time-tables and political pressures. Just as the social problem had been identified with squalid housing, so the solution became identified with housing of another kind — and the more spectacular the physical contrast, the more impressive the image of reform.

The director of the Lagos scheme was an engineer by training, and he saw the rehousing estate's difficulties as problems of social engineering to which a solution must exist. In common with men in many countries, rich and poor, he had accepted the task of changing society by changing its buildings. The clearer it becomes that such changes could not be accomplished in this way, the more they are driven to self-deception and counter-accusations to protect their identity as sincere reformers. Their personal predicament reflects a fundamental drawback of all idealistic slum clearance schemes.

Slums as Social Symbols

When people are forced to move from a familiar neighborhood, they lose, most obviously, the habitual physical setting of their lives. To the planners who move them, this setting is a slum — dirty, dilapidated, overcrowded and dangerous to health. The signs of dirt and decay can be powerfully persuasive. Visitors to the alleys of old Lagos have often been shocked by the ordure floating in the muddy rivulets over which they had to pick their way, by the dark rooms with stained and patched walls, by the jostle of livestock and naked children. Yet the area was full of prosperous families, had a flourishing trade, and was close by the best medical services in the country. Dirt is laden with connotations of danger and corruption once it is perceived as something anomalous and disordered. But the lives of people in slums are not necessarily disorderly, and they may not notice the dirt or see it only as an incidental nuisance. They would like more space, better drains, repairs — but to achieve this only at the cost of destroying the neighborhood itself seems to them a distortion of what is important. If the physical setting has one meaning to the planning authority, it has another to the residents. The corner shops, the shabby streets, the yards and lots where they played as children are invested with all kinds of intimate associations. The neighborhood is a part of them, and to hear it condemned as a slum is a condemnation of themselves too.

The condemnation may be explicitly personal. To the authorities, decay and obsolescence suggest economic backwardness and poverty. Hence, if the residents cling to their slum, they too must be, at best, appallingly ignorant of the possibilities of life, and at worst morally corrupt. Slum clearance acquires a missionary zeal. In Nigeria, the Minister of Lagos Affairs described the slum area as

"a humiliation to any person with a sense of national pride"; and the principal daily newspaper commented censoriously when the residents attempted to defend themselves against eviction:

> The spectacle was saddening, and it was bound to arouse the anger of every lover of Nigeria and those who rightly feel that Lagos should, and can, be a worthier capital. It sould have occurred to the occupants, and their leaders in particular, that by indulging in foolhardiness, they had only themselves to blame if the police, with Nigeria behind them, got the better of them.

Thus Lagos slum clearance involved a conflict between incompatible conceptions of the place itself. If central Lagos was not a "slum," then all kinds of beliefs about modernization and nationhood were invalidated; and if it was, then the people who lived there were betraying the aspirations of their country by insisting on their right to be themselves. The merging of social reform in slum clearance, therefore, leads to the insistence of authority that in moving they must change not merely their surroundings but the way they live. If the new home is adaptable to their way of life, the adjustment is soon made — the same conventions of neighborliness apply, the old patterns of shopping, meeting, visiting find their counterpart in new spaces. But when any restoration of a familiar pattern of relationship is frustrated, people cannot assimilate the change without continuity; they are bound to evade the purposes of slum clearance in any way they can. The outcome can be destructive, not only for those residents without resources to defend themselves, but for society at large, which finds its ideals committed to issues for which there is no humane resolution.

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A Plan for Supplying Services to Squatter Settlements in Zambia

Paul Andrew, Malcolm Christie
and Richard Martin

[Half the people of Lusaka, Zambia, are living in squatter settlements, which have certain advantages for their inhabitants as compared to authorized housing. But they lack drinkable water and sewage. Methods for providing these and other services to such areas in accordance with plans appropriate to their current needs and future growth are proposed.]

An important feature of the colonial administration in Zambia was a complex legal system of controls. To take housing as an example: (a) most housing is tied to the job, so free movement between jobs is impeded; (b) it is not permitted to trade from or derive money from an activity undertaken in a house; (c) you may not grow maize or bananas (staple crops) as they are said to be bad for public health; and (d) lodgers are not allowed. And while the standard of housing improves, the layout continues to be rectilinear and mechanistic — a total contrast to the idiosyncrasy of village planning.

Before independence there had been in Lusaka (capital of Zambia) an influx of people into unauthorized settlements, as they were known. The most common origin of these was contractors' camps. An area was set aside for contractors whose men were allowed a few days off at the beginning of the contract to build themselves a grass hut. By the end of the contract this hut was often quite substantial. Although the con-

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tractor was then supposed to demolish the huts, he usually did not, and in many cases the compounds became permanent. Non-contractor people infiltrated, and the situation went out of control. The settlement with which we are concerned here started differently: a businessman saw a way to easy money and let out small plots for 50 pence a month, thus netting an annual income of several thousand pounds from land that was worth very little indeed.

Whatever the origins of these areas they remained unnoticed by nearly everyone until after independence, when suddenly they began to mushroom in open defiance of landowners. Squatting, in the sense of taking over someone else's land, has continued unabated until the present day, in spite of various attempts by the Government to halt the process by demolishing huts here and there. One in every two persons in Lusaka is now a squatter.

In spite of the lack of a piped water supply, sewerage or proper roads, conditions in the squatter areas are, in aggregate, much better than they are in the villages in Zambia. At least in town there is easy access to shops, clinics, schools and the rest. But of course the most important reason for living in a squatter area is that in town there is work, and work brings money. Most of the squatter areas are noticeably well situated in relation to workplaces.

Squatter Settlements

Squatters are not all, by any means, peasants new to towns and the money economy. A substantial proportion of young couples brought up in Lusaka have nowhere other than squatter areas to live. They are not necessarily poor: 96% of the householders are employed or self-employed, and of those who have jobs 80% are well above the "bread line" which is K17 per month for a family of five, as the minimum industrial and Government wage is K30 per month (one Kwacha = $1.58).

Rural-urban migrants do not immediately start building themselves a house in a squatter area. They first locate a relative who may be living in a council house or a squatter area, and then when job opportunities look good they will set about house-building. It is often at this stage that the wife and family arrive. The extended family as known in the villages does not exist in the squatter areas. The nuclear family, usually living in one or two rooms, is almost universal, and where extended families exist they are not living as such but form a sort of dispersed mutual welfare society.

A number of highly sophisticated ways of controlling public behavior have evolved, all of which are administered by the political party, UNIP, and derive in some measure from the traditional powers of the chief. Two examples will suffice: 1) Plot allocation: no house may be started

or sited without the knowledge and consent of the Party. A new applicant must first have a sponsor from within the community, and must produce a certificate to prove his Zambian citizenship and membership in the Party. If possible a space will be found for him somewhere near his sponsor, especially if he is a close relative. In any case the UNIP section leader of the area where he is given a plot will be approached and asked his opinion — in the same way as a village headman would be involved. 2) Water and latrines. Wells are considered private property and so are latrines; the former are used by a known group of people, and the latter by each family. Newcomers are allowed to use a well, but if, as often happens, it dries up and a new well is required, all those who wish to use it are expected to help. If anyone refuses he will not be allowed to use that well unless he pays for the water.

Innumerable parallels can be drawn between the organization of rural villages and squatter communities, not only in social aspects but in the physical organization which is extraordinarily similar to many villages. The common ingredients are size (about 20 huts), use of space (a common open space in the center, with private and semi-private open spaces off it and between the huts), physical groupings (approximating to the circle) and a broad overlapping of land use, with a general absence of any cultivation within the village. In the squatter areas this physical separation of one village unit from another is not immediately obvious — in fact it takes a detailed analysis to demarcate them. For example, the position of the doors facing the center of the circle is significant. They develop into a traditional urban hierarchy, more or less as follows:

20 families = 1 village group (community) with 2 wells, 1 shop
200 families = 1 UNIP section with 1 bar, 1 butcher
2000 families = 1 UNIP branch with 1 school, 1 market, 1 assembly place.

Life Style and "Government"

There is a system of beer and work parties in Central Africa called cima by the Bemba — Zambia's biggest tribe. A man who has a particularly difficult and urgent job to do can call his fellow villagers to help him; in return they are freely entertained when it is finished with plentiful beer which his wife has brewed while they have been working. Our squatter areas are the same: where there are zones of mutual self help a highly efficient workforce can be summoned at any time.

The physical layout allows a life style that is not the stereotyped urban existence which is a poor imitation (physically speaking) of the European colonialists, and is not the introverted life of the small village. Instead it is an urban African life where rich allowance is

made for the traditional role separation of men and women, where distances between buildings are based not on British Public Health Regulations but on shouting distances, which enable women while cooking to talk to each other without straying from their door, while conversing at the top of their voices. To us it sounds like shouting: to them it is normal outdoor speech. It enables a fluidity of house planning, particularly in regard to the onerous avoidance rules which relate to parents-in-law. The unitary one-entrance "European-style" house causes acute embarrassment in this respect, embarrassment that can only be cured by a separation of the various areas of the house.

One of the most important ingredients of the life style is the freedom from petty legislation. Thus the people may have lodgers, they may suit the size and standard of their house to their pockets, they may trade big or small and set up service industries such as motor car repair, tailoring, etc.

In fact, it is thanks to their exclusion from the law by their first gesture of breaking it that the people have had to make a sort of unilateral declaration of independence. In so doing they have no longer to depend on the bureaucracy; instead they can evolve a more relevant machinery. This machinery is the Party, already well established on the cell principle and with virtually universal membership. Through the Party the people can decide what should and what should not be controlled, and through the Party unacceptable members of society, "trouble-makers," are expelled from the area, losing their house in the process. The Party is not an informal government: strict hierarchical rules apply. But it is a people's one, and it is remarkable to witness the speed with which those within it who do not perform satisfactorily are replaced in the annual elections. Of its connection with official Government, little is said.

Infrastructure and Life Style

One should not underestimate the great hardship that the total lack of water fit to drink imposes on the squatters. Some people drink unfit water, as the incidence of stomach complaints shows, but the conscientious mother must either boil it — having first let the mud settle to the bottom — or fetch it from a tap several kilometers away. Similarly the roads in the wet season (November-April) become quagmires which make walking difficult and very messy, and driving nearly impossible. Many houses cannot be reached by car in the present conditions, and residents are very concerned about ambulance and police vehicle access.

Is it possible to introduce mechanisms such as piped water and properly built roads into a non-mechanistic jig-saw puzzle in which the degree of interlock is infinite? Is it worth destroying one to obtain the other? Are these mechanisms really worth the expense and trouble,

or would we be merely burdening the people with services they do not want and cannot pay for? The last question is the most important, and the answer — we can testify from having had it answered by ecstatic shouts at a public meeting — is that the services of roads and water are needed as much as most of us need them: they are essential for a decent existence, and the squatters will both pay for and install them if necessary.

There lay the answer: a cima solution for a cima society — an extension of the beer and work party from three days work to three years. Not only were the people prepared to spend money on rates for services, they were prepared to install them. Each community (of 20) could be its own planning committee to decide priorities, location of pipes, spread expenditure fairly, and organize its own labor programs. And so that no group would delay the progress of another community the mains would be laid between the groups. The mains, being high technology and needing speedy completion, would be laid by a contractor. In many parts of George, the squatter area used as a test case, there are pockets of unused grassy land for pipe laying between the communities.

The following features appear to be essential for consistent success in this type of scheme: Group work, preferably based on existing loyalties and ties, but if necessary among strangers. Groups of a suitable size. Something between 16 and 25 families is right: more and the group loses cohesion, less and it becomes too dependent on individuals. Independence of the groups. If one group is dynamic it must be able to achieve its aims at its own speed: others must not be allowed to retard it. Likewise the example of successful groups will act as a spur to others. Flexibility. Those who are poor (either within the group or as a group) must not be crippled by coercion to give funds, so the program must be tailored to available means. It is not possible or desirable to design water and sewage facilities for every house. People on the ground can decide not only the route of the services but also when they want them. Financial Independence. Dependence on Government funds creates an atmosphere of passivity and helplessness. It is clear that any Government funds for this type of project will be very limited and therefore expenditure should be limited to essentials. Together with expenditure go controls, so by maximizing popular financial and physical input one maximizes freedom of choice. Also, by developing with locally generated funds, the vandalism and disregard for publicly financed improvement measures will be avoided.

The Plan

The application of this thinking to the squatter settlement called George is illustrated by a plan. The work is divided into two parts: contractor-installed services, which would be installed with govern-

ment or local authority funds; and self help services. The former would include sewers which must be laid adjacent to each community in such a way as to prevent sectional conflicts. The latter, e. g. the water pipes to houses, would be provided as and when required. We give an example of one community's development under such conditions; it is no more than a prediction, which will be affected by the way in which people use the servies and the priorities they adopt. The time scale will be related to the energy and financial resources which are not easy to predict, but it is certain that parallel with an improvement in the servicing will go a regeneration and remodelling of the buildings served. With these qualifications, a little crystal gazing is appropriate.

1. As an interim measure, while people are saving up for better things and planning their community, a single tap is allowed for in the middle of the community area. This is linked by a run-off trench to a garden area down hill. The access road is improved by the people it serves, while the main road network is being gravelled and properly constructed. Suitable gravel is made available to the people for the work.

2. One house, one tap (like one man, one vote) is a sort of article of belief when you have struggled for so long to obtain drinkable water, so it will not be long before the taps are installed. Helped by technical assistants, but paying for the materials, the people will be able to place these when and where they like.

3. The installation of a sewage system is an altogether more complicated process and takes time. The existing layout suggests that it is very difficult to obtain a straight run of more than a few meters, and that the installation of a sewer system would be difficult. But there are two important aspects to be borne in mind: a pipe is only the width of a trench, say half a meter, and a straight line of that width can be integrated into very haphazard layouts. Secondly it is cheaper to put joints in pipes than it is to demolish a house and rebuild it.

Implementation. We are lucky, when considering a possible procedure for implementation of this physical strategy, that Government has issued a little green book laying down a machinery for consultative and participatory decision making in matters of development. The main instrument in this machinery is the Ward Development Committee (WDC). The population of a ward is about 10,000 people. Our plan can be said to be completed when: 1. All residents know what is happening. 2. The demarcation into communities has been undertaken, and has been checked from the point of view of servicing practicality.

Clearly the personnel of the WDC can play a leading role in this

process, particularly as its links with the Party organization are very close. But trained community development workers must work hand in hand with them, particularly with a view to resolving demarcation and cooperation patterns, and clearing the air for motivation from a grass roots level that will not be frustrated by bureaucracy and irrelevant controls. One of the inevitable zones of friction will be between the community development workers and Party officials, some of whom have a tendency to authoritarianism.

Once this demarcation has been achieved the problem becomes more specific. In many groups there will be drop-outs, spendthrifts, pushers and excluders, and skill will be needed to handle these conflicts. There will also be technical problems for which skilled advice will be needed. Finally, there will be problems, for some people, of funding the exercise. For all this, skills must be made available in strength; unaided the people will not be able to achieve their potential.

There are two ways of meeting this need. The obvious one is for the local authority to supply technical assistants, community development workers, and a materials store for concrete blocks, pipes, etc., which may be bought at a reasonable price. This procedure has been the standard practice in Site and Service schemes for years and works quite well. The second alternative is to aid the people to establish these skills as entrepreneurs. With the exception of community development work, the other skills are found in all societies anyway, and in other parts of Africa are developed to a high degree. As it is, a high proportion of residents in squatter areas work in the construction industry and it is to be hoped that the community would capitalize on the presence of plumbers, drainlayers, bricklayers and carpenters to train themselves in the simpler tasks and build up each other's businesses where specialized labor is required. Whichever method is adopted, it is important that the 'project' be at such a stage that when any assistance from the Local Authority is withdrawn the residents will be more skilled and more self-reliant.

Landlordism. At least one quarter, and in some cases half the households live in rented accommodation in the squatter areas. Usually a family will live in one room for which they will pay about $6.50 a month. (The figure derives from the fact that those who earn less than about $45 per month and are not provided with a house must receive this much as a housing allowance from employers.) The landlord thus receives an annual rent of $75 per room, which with its mud brick walls, skim-coat cement floor and galvanized iron roof will cost about $75 to build. This very high return on investment encourages those with limited means to build more houses as a supplementary source of income, and most landlords have bery limited means. Thus the housing allowance system generates house construction by

landlords and increases the wealth of the squatter community. On the other hand if landlords are in a position to corner the market by making it difficult for others to build themselves houses, or if government controls have this effect, an exploitational system will evolve very rapidly. There would be no incentive for landlords to contribute to the costs or labor of upgrading communities, and the system we are proposing would not be appropriate.

This situation does not exist yet, but it must be carefully guarded against to prevent its happening. The present tendency is for rented accommodation to be acting as a holding ground for people looking around for a house to buy, a plot to build on, or simply a better job which will enable them to save. Initially new immigrants to the town will live with relatives, then go on to rent a room and later find or build a place of their own. However a machinery to involve landlords in the upgrading process is essential. Probably the most successful influence is popular pressure; an institutional method of bringing this to bear is outlined below.

Planning institutions. Improvement brings aspirations to a set of values that does not necessarily fit the existing situation. For instance, whereas the traditional layout is of houses on common land with private land being reserved for specific functions, a new outlook may develop which demands a properly demarcated plot. A steady increase in individual wealth may well give rise to anti-social tendencies which, if allowed free rein, will totally disrupt the workings of the community at a physical and social level. It is therefore essential that the community at large have a democratic and effective machinery for preserving the physical characteristics of the settlement that are necessary for its viability. And among these we must include the lack of formally divided plots, for the multi-use of space is the only reason for the apparent densities being so low.

For another equally good reason it is essential to establish control over land use and clarify the status of the residents. At the moment the squatter land belongs to others, and there can therefore be no security of tenure. Government has already announced plans to acquire the land, under its compulsory purchase powers (if necessary). We propose that the land should be given back to the people on a 99 year lease at a nominal rent. To administer this land we propose an extension of the present Party system — a cooperative administering the area. The cooperative would designate areas to be left free for community facilities, would allocate trading sites, would give permission for house extensions etc. It would be similar in organization to the present Party system: one community (20-25 houses) equals one section, 10 sections equal one branch, 30 branches (or thereabouts) to the whole cooperative.

The "cabinet" of the cooperative would consist of the 30 branch chairmen; the "assembly" would consist of all section leaders. In this way each community would be assured of a voice. The resolution of basic technical and engineering decisions, pressure on landlords, assistance of the poorer and weaker, etc. would all take place at section meetings at which all the households would be represented. Branches would concern themselves with inter-section liaison and cooperation, while the cabinet would make recommendations on land use and resolve disputes that cannot be settled at a lower level.

One of the major tasks for the cooperative would be to assist and monitor the thinning out/expansion process. Both are an inseparable part of the next stage in the evolutionary pattern. Adjacent land must be made available for settlement by lodgers and the underhoused who, by moving out, make more space available for the improvement and consolidation of the remaining houses. Combined with the permanency of tenure and improvement of services, this will have a crucial effect on the ultimate housing standards.

Alone, such measures will be more than swamped by pressures from other residents of Lusaka. But two factors make it possible that within five years the pressures could be reduced. The first is that squatter areas throughout Lusaka may be given water supplies and be legalized under a recent policy statement. The second is that a massive program of provisions of plots for self-help housing has been launched which will help to absorb the natural increase in population and the better-off urban immigrants. The overflow areas should be administered under the adjacent cooperative, and as each new community is established it takes its place within the overall cooperative framework. Likewise the servicing will be done on the same structuring principle: mains only provided, smaller connections left to the people to provide as and when they can. Layout of houses can be quite free within the zone encompassed by the service grid.

Rather more difficult to accommodate will be schools, clinics, bigger markets, and perhaps playing fields. Peripheral sites must be reserved for these, while the overall size of the settlement is such that they would not be more than 3 km from any member of the community. An illustration of this type of process has happened recently. The existing market in a central location was far too small. The possibilities were discussed at length by the Party and the WDC. Eventually it was decided that it was better to have one large, properly fenced, secure market than a number of smaller ones. A cooperative was formed, registered with the government, and over a holiday week-end an area of about one hectare was appropriated, fenced and work on about 200 stalls began.

Squatter University

One of the differences between living in a squatter area and an 'approved' area is that the latter is controlled. The absence of restraints in squatter areas means that anyone — even if his capital amounts to only few kwachas — can try his hand at some kind of business. Likewise the cultural ambiance in a squatter area has all the nuances of a genuine evolution from rural to urban living. Thrown into this society the newcomer from the rural areas assimilates the urban outlook at an easy pace, and can adjust to the harshness, speed and insularity of the money economy over a period of years. What we may call the Squatter University is developing skills, evolving new social systems, teaching the newcomers, giving opportunities for experiment and experience to the better established members.

It is worth listing the courses which the squatter university offers: urban living; local government (e. g. allocation of plots, organizing marketing, settlement of disputes, maintenance of law and order); planning; public health (e. g. rubbish control, siting of wells, drainage); building; retail and wholesale trading; manufacturing; banking (e. g. credit union organization); market gardening; service industry (e. g. repairs to shoes, watches, radios, clothes).

What we are witnessing is the evolution of not only a new urban life style but also the first post-colonial planning system, in which the dynamics, traditions and special qualities of Africa are given a chance to develop their own urban system.

[Extracted from "Squatters and the Evolution of a Lifestyle," Architectural Design, Vol. 18, No. 1, 1973. Copyright©, The Standard Catalogue Co. Ltd/Architectural Design, London England.]

A squatter settlement nearby and similar to George. (Photos: Jeffrey Cohelan)

Representative Houses

Community Market

New Construction

Social Transformation and Urban Growth in Rio de Janeiro

Jose Arthur Rios

[The burgeoning population growth and the spread of squatter areas in Rio de Janeiro have been of concern to government for some years. Various kinds of solutions have been successively applied, including localized housing projects, politically sponsored action groups, and mass housing construction. Social implications are explored.]

The city of Rio de Janeiro has been the focus of important experiences in urban renewal and social transformation. For many years the principal port and political capital of Brazil (until 1960), its population has been growing rapidly in recent decades. By the thirties, Rio developed a great many industries involving a considerable number of factories and workers, and a current of low class migration from rural areas made up of unskilled laborers, small craftsmen and shop keepers speeded up the city's rate of growth. Up to that time the housing problem had been solved by the existence of suburban areas where low cost land and houses could easily be found. However, this area became insufficient and inadequate for newcomers as the cost of the land and the building of houses within the framework of urban regulations proved beyond their means. Many of them did not even earn the minimum salary which social legislation granted them. Since jobs did not grow at the same rate as the flow of migration, the expansion of the city economy did not parallel and support the population upsurge. The imbalance resulted in social "marginalism," a term which expresses the instability of people who are not able to insert themselves into the social structure by holding permanent jobs, by owning property, or by being entitled to use urban facilities.

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In order to survive, it is essential for such people to live in rent-free areas a short distance from the source of jobs, whether this be factories, shops or middle and high class residential neighborhoods. The only available areas were abandoned hill tops or vacant land among buildings. In such areas they started building their shacks, which soon mushroomed to become huge favelas (slums). In time, however, many of their dwellers were able to climb the urban social ladder, and ascend to the heights of the minimum salary and social security benefits, by peddling goods or by obtaining a job in the bureaucracy. Slowly a lower middle class began to emerge in the favelas; the shacks became houses built up with more solid materials, painted anew; sometimes they gained another floor. Between 1950 and 1960, the favela population increased to 335,063 (97%) and between 1960 and 1970 to 562,062 (67%).

These numbers do not include the population of "slum" areas not designated as favelas in the census classification but given other names. These were estimated in 1960 to shelter 400,000 people. Corticos and cabecas-de-porco resulted from the deterioration of old settled areas and high class mansions invaded by the same kind of people who made up the favelas. They were motivated by the same need to place themselves close to their source of income and work. The rapid decay of old buildings brought about by the high valorization of land in former aristocratic areas afforded them the chance to keep this strategic position paying a small rent or no rent at all. In short, at the end of the fifties, marginal housing in Rio sheltered a population estimated at approximately one million people.

When prosperous, some favelados started looking beyond the narrow horizons of their favelas, seeking for their own home, freedom from insecurity and threats of varying nature. They resorted to the land subdivisions (loteamentos) opened up by land speculators in distant suburbs on the outskirts of the city. This resulted in a new type of urban aggregate, a mecca for the lower middle class, for small shop-keepers and retired people from the minor ranks of bureaucracy. They were able to afford it because land was sold in small installments and on long-term payments.

First Efforts at Control and Reform

Both the Federal and city governments, frightened by the so-called social problems of the favelas, started as early as 1940 to take measures for slum clearance and control. These measures were both negative and positive: they included the prohibition of building new shacks and the destruction of entire favelas; they also created new public and private agencies to finance or to build new houses. Since 1941, the so-called Institutos de Aposentadoria e Pensoes have committed themselves to building low class housing as well as houses and

apartment complexes financed by the Federal government. The city government established the Departamento de Assistencia Social; later on, the Divisao de Habitacao Popular was also created to develop plans for the new buildings. Private organizations were established by the Catholic church for the same purpose: the Fundacao Leao XIII (1948) and in 1955, under the leadership of Archbishop, Dom Helder Camara, Cruzada Sao Sebastiao.

These new agencies generated a process of guided urbanization and slum clearance which seldom took advantage, and in many cases, ran counter to the spontaneous processes of urban renewal. In 1942, the first Parques Proletarios (workers' parks) were inaugurated by the city government. They started with 550 wooden dwellings built up along regular lines, and they incorporated a social work center, a school, a nursery, a church and a medical center. Soon, the attempt at control was given up and the so-called proletarios, mostly low-rank public servants, home servants, peddlers, and temporary workers who had received their home through some friend or political boss, and who did not pay for the shelter, started inviting in their own friends and relatives. Either by bribery or political pressure, they were able to expand their homes or to build new ones, therefore defeating the planners' original intentions of cleanliness and regularity. The Parques then became true favelas.

The same happened to the government houses built up by the Institutos. As soon as the dwellers were left to themselves they would start setting up new partitions, breaking window panels, selling the metal parts of the bathrooms, destroying privies and fitting as many people as possible in the rooms. They became urban ghettos. The Cruzada Sao Sebastiao was only able to avoid the same problems by keeping a permanent staff on the spot to control misbehavior and "educate" the favelados. As to the Fundacao Leao XIII, it limited itself to extending to some favelas the same services which benefited the Parques — medical assistance, social work, schools, nurseries, etc.

All these so-called solutions, which received much attention and propaganda, reflected an implicit paternalistic approach. None of them tried to incorporate the favelados as decision makers or tap their ability to extricate themselves from misery. None tried to organize them into voluntary associations in order to strengthen their bargaining power. Finally, the core of the problem, the possibility of creating new jobs using their own skills and qualifications, was not even discussed. Favelados, on the other hand, developed techniques to adjust and take advantage of their situation. They would organize themselves through local leaders, favelados themselves or outsiders, and use politicians to apply pressure on the city Executive, sometimes obtaining through him everything they wanted, from water fountains to jobs.

Political Solutions

This situation changed substantially in the first years of the sixties. A few isolated experiences began to germinate. In one small favela, for example, the residents themselves (under the able leadership of one of their own number and the stimulus of a social worker from Cruzada Sao Sebastiao) rebuilt their shacks as brick and mortar houses and were able to change the favela into a bairro (urban section). This meant that the houses became legal (favela shacks are not) and received street numbers, and their inhabitants started paying taxes.

The political crisis of the period deeply affected the favelas. They became a great topic of argument and discussion, and public opinion became so interested in their problems that a newspaper of wide circulation, O Estado de Sao Paulo asked a private organization to study them. Although they were illegal, (i. e. not recognized by the city government) water, light and sewage were extended to many of them and a special census was taken of them. The favelados learned to organize themselves into local associations more or less backed up by politicians, and candidates for public office sought their support.

In 1960, Rio elected its first governor and favelas were a topic in the political campaign. Local associations were strengthened, and favelados were induced to contribute their labor to the opening of streets and bypasses, to the building of schools and medical posts and to small cooperative projects. The idea behind the plan was to build into the local association a strong network of cooperatives to which would be entrusted the work of urban renewal itself. But an operation of such scope depended upon the support of the Federal government, unthinkable at that moment. The building firms in Rio have always represented a strong group and they were bound to favor the total eradication of favelas and/or their substitution by huge new complexes in the outskirts of Rio. The same Government that had fostered solidarity and cooperation among the favelados ended by upholding a policy of favela eradication, and delivering control of their land (mostly in fashionable areas) to national and international concerns which built new hotels and tourist places.

CHISAM: Mass Government Housing

In 1964 a new approach was adopted. The Federal government created a National Bank for Housing which was to work through two departments: the Financing System for Housing, and the Labor Security Fund. As of 1968, however, both the Financing System and the Housing Cooperatives who applied the huge resources of the Fund, in agreement with the labor unions, seemed to have failed in the slum area. Favelas continued to spread and there was no coordination of the Federal and State efforts at urban renewal in the Rio area. This

led to the creation, in March 1968, of another agency, the Coordination of Housing of Social Interest in the Metropolitan Area of Greater Rio (CHISAM). The studies made by this agency stressed the following points:

1. The slum problem generally had grown to such an extent that it never could be solved by local governments alone because it extended all over the country.
2. The control of migrant waves moving toward Greater Rio could be effected only by the Federal government and not by the State government. Part of the slum population comes from other States, and settlements cross State boundaries.
3. Resources would be fragmented by State government agencies acting in slum clearance plans while Federal government and private agencies followed different policies. It would be possible to solve the problem in practical terms only through a joint effort on the part of the Federal government, the State governments, private agencies and the slum-dwellers themselves.
4. The social consequences of constantly growing slums demanded immediate organization and short, medium and long term action.

According to the estimates produced on that occasion, the number of marginal dwellings in the area of Greater Rio was 200,000 and contained 1,000,000 inhabitants. Replacement of these shacks by adequate homes would require one billion six hundred million cruzeiros (over $350,000,000). This sum did not include resources necessary for water supply, a sewage system and street lighting or the value of the land and the operating costs. These estimates spiralled even more when it became clear that the population growth of low income families was 7% yearly. By calculating an average of five persons per dwelling unit, it was found that it would take 14,000 new dwellings just to meet the slum population growth. At an average cost of 6,800 cruzeiros per unit in 1968, the annual investment required would be 95 million cruzeiros just to keep the number of shacks from increasing.

Huge sums have been invested in CHISAM programs, a total of CR$351 million up to March 1971. These investments led to the building of 35,157 dwellings (between November 1968 and March 1971) at an average construction cost of 7,000 cruzeiros per dwelling. The National Housing Bank supplied 85% of the funds. The types of dwelling included the following:

One bedroom apartments	7,011
Two bedroom apartments	16,623
Three bedroom apartments	10,833
Houses, one to three bedrooms	690
	35,157

As of December 1971 thirteen housing complexes were completed with 19,880 apartments, which were to house the 87,430 inhabitants of 32 favelas. The construction program includes units of all types, sizes, and rentals ranging from 20 cruzeiros (US$4) to 130 cruzeiros (US$26) monthly. Before proceeding with the eradication of a slum, its dwellers are classified according to levels of income. The basic idea is to keep the average monthly payment per family within the legal minimum salary (CR$226 in 1971). Housing cost should not exceed 25% of the total family income (man and wife). The financial arrangements for purchase are shown in Table 1.

Table 1

Nature and type of units	Nature of dwellers	Sales price	Average payment Cr$	Period of financing	Average interest
a. Transfer units and Centers of Social Dwelling (*)	Less than the minimum salary	-	Tax 20 monthly	-	-
b. Houses of varying sizes in specially built communities	1 and 1.5 times the minimum salary	6,500.0	40	20	4.5
c. Apartments with one bedroom	Two minimum salaries	6,895.0	70	20	7
d. Apartments with two bedrooms	Two minimum salaries	11,992.5	105	20	7
e. Apartments with three bedrooms	Two minimum salaries	13,500.0	130	20	7

(*) These dwellings are not sold but occupied temporarily.
SOURCE: Banco Nacional de Habitacao (1971).

In order to carry through CHISAM's programs of "social integration" other measures were taken — for example, the establishment of reserved apartments for low income families that were not resident in the eradicated slums but lived in poor conditions, although at slightly higher levels than the slum dwellers. For the same purpose, trade training courses, schools, cooperatives, community councils, business locations, recreation grounds, religious cults areas, health posts, communication agencies and offices for the registration of deeds and charges were also established within each residential complex.

CODESCO project. Before commenting on CHISAM's programs, something has to be said about another development following quite independent lines. This is CODESCO (Companhia de Desenvolvimento de Comunidades) established by the State Government of Guanabara in March 1968. After a preliminary survey, the following conclusions were reached:

a) In order to plan slum clearance the definition of land ownership is fundamental. The favelado does not own land but wants it.
b) Investment in housing is directly related to a feeling of security as to land ownership.
c) Any plan should aim at strata not covered by the National Housing Bank program, which concentrated on those who earned between 1 and 3 times the minimum salary.
d) Any plan should keep the favelado within the same administrative region, i. e., within his area of work.
e) Any plan should include the favelado's participation as well as his conceptions about his own house.

CODESCO planned to be instrumental in the State's housing policy and act at the same time as a financial agent of National Housing Bank. However, not only were its assumptions different from CHISAM's but also its way of working. Having chosen the favela to be transformed, a public bid calls for a building concern which will take care of the planning of the public services (water supply, sewage, electric energy, etc.). The second phase is the housing program, based on self-help by the favelados with financial help from the Bank for building materials paid in installments over a long term at low rates of interest. Individual house building falls to the favelado himself who is helped by a team of architects and engineers.

In order to achieve these results the favela community is encouraged to participate in the program through several techniques of group work. The overall purpose is to transform the favelado into a home owner so that he will become independent, secure, and a tax-payer. Self-improvement of the dweller is sought by asking him to share responsibility in the planning and building of his home. So far CODESCO has completed the urbanization of two favelas and surveys of eleven.

The CHISAM philosophy. In the CHISAM system of slum clearance the following assumptions are made: Urban renewal problems can be solved through the replacement of shacks and favelas by new houses and apartments. The "social" problem of the favela is solved by lowering the cost of building so that as many houses as possible will be within the reach of the low income classes. Housing per se becomes a social solution. Newly-housed people will incorporate new patterns of behavior into their lives and will become "promoted" or "educated." It follows from such premises that the favela problem has a definite

deadline. Favelas will be totally eradicated, in the initial plan, by 1976. This goal is set by estimating the present number of shacks, the output of new building and the input of money.

The whole system was created by financiers and economists, specialists who have equated social transformation and social ascent to one variable, housing. The emphasis on eradication and the building of new houses has the effect of liberating valuable land for middle and upper class apartments and for fashionable hotels, as well as opening up a wide market for building concerns in Rio. Thus, once again, building entrepreneurs, a powerful group at the summit of Brazilian society, receive a tremendous injection of money. It has also had the side effect of increasing the demand for labor in building.

CHISAM's philosophy of work is permeated by a paternalistic and benevolent attitude towards low class people which is traditional in Brazilian society. Its form of operation is bureaucratic. Since the favelado has to be "educated" for favela eradication and "re-educated" for adjustments to new houses, an army of architects, sociologists, social workers and auxiliary personnel is needed. This adds a marginal benefit of opening up new jobs in the tertiary sector.

Previous experience, however, does not seem to support CHISAM's basic assumptions. It is impossible to consider favela growth in Rio as stabilized; quite the opposite. Favelas keep growing, and now the residuals of eradication, i. e., those who do not even enter the lower ranks of candidates for home ownership, are ejected to favelas in the outskirts of Rio which have been growing at a tremendous rate. It is well known that favelados have a higher fertility rate and that intra-urban and rural-urban migration keeps going on, due to low levels of living in the interior and the failure of the middle class to expand. For those who think that the core of the problem is the creation of new jobs by unorthodox techniques and not the building of new houses, the priorities shown in the CHISAM system are a tremendous waste of money that could go into creation of permanent jobs. The same, however, cannot be said of CODESCO. Although it is an example of induced urbanization, it greatly depends on the favelados themselves, on their social organization and style of living.

It is apparent that CHISAM and CODESCO feed on opposite philosophies. CHISAM, a federal agency, has the full support of the government and great resources. CODESCO work, more subtle and sophisticated, depends on know-how. So far, it does not seem that CODESCO, whose work has been limited to a few favelas, will prevail.

It is possible that new ways of spontaneous urbanization, less costly and less detrimental to favelados, can be devised. The experience of the lower-middle class subdivisions seems to show that, given a minimum of urbanization and given facilities to buy building materials, social solidarity does the rest. This, however, calls for more sociological ingenuity and a totally different approach to the problems and pains of the classes in Brazil.

[Extracted from "Social Transformation and Urbanization: The Case of Rio de Janeiro," Urban Anthropology, Vol. 3, No. 1, 1974, pp. 94-109. Brockport, New York: Department of Anthropology, State University of New York (SUNY — Brockport).
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